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CHARLES MORTON'S
Compendium Physicae

Committee of Publication

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Morton's Compendium Physicae

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Preface

FROM its inception The Colonial Society of Massachusetts has shown an interest in every phase of life in Massachusetts before the national period. This, however, is the first of its publications to be devoted exclusively to the field of intellectual history.

The plan to print Charles Morton's Compendium Physicae *was first sponsored by The Club of Odd Volumes, and it was through their initiative that this volume was prepared. When it was decided not to carry the undertaking through to completion, The Club of Odd Volumes generously presented to this Society the completed manuscript, ready for the press.*

To that organization our thanks are primarily due. Various libraries, both here and in England, have coöperated through making available the various copies of Morton's manuscript in their possession. Our fellow-member, Mr. Theodore Hornberger, has been untiring in the collation of these variant texts and in the preparation of the index.

For the Committee of Publication
SAMUEL ELIOT MORISON, *Chairman*

Boston, July 1, 1940

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Table of Contents

Page
BIOGRAPHICAL SKETCH OF CHARLES MORTON vii

INTRODUCTION TO THE *COMPENDIUM PHYSICAE* xxxi

COMPENDIUM PHYSICAE

The Preface 3

Chapter 1. Of Physicks or Naturall Phylosophy in Generall 7

Chapter 2. Of the Generall Part of Physicks 9

Chapter 3. Of the Affections of Body in Generall 15

Chapter 4. Of the Speciall Part of Physicks, First the Heavens in Generall 20

Chapter 5. Of Heavens in Speciall 31

Chapter 6. Of Terrestriall Body and of the Elements in Generall 36

Chapter 7. Of Elements in Speciall, and First of Fire 42

Chapter 8. Of Air 47

Chapter 9. Of Water 53

Chapter 10. Of Earth 73

Chapter 11. Of Mixt Body in Generall, and Its Affections 78

Chapter 12. Of the Species of Mixt Bodyes, and of Fiery Meteors 81

Chapter 13. Of Comets 89

Chapter 14. Of Aery Meteors 94

Chapter 15. Of Watry Meteors 100

Chapter 16. Of Appearing Meteors 108
Chapter 17. Of Perfect Mixt Body, and First of Stone 113
Chapter 18. Of Mettals and Mineralls 117
Chapter 19. Of Animate Bodyes in Generall and Speciall Vegitable and Sensable 126
Chapter 20. Of the Growing Faculty 134
Chapter 21. Of Procreation 139
Chapter 22. Of Sensitive Living Bodyes 149
Chapter 23. Of Seeing 152
Chapter 24. Of Hearing 163
Chapter 25. Of Smelling, Tast, and Touch 174
Chapter 26. Of Interior Senses 180
Chapter 27. Of Sensitive Appetite 185
Chapter 28. Of Locomotion 187
Chapter 29. Of Secondary Affections, Awake and Sleep 194
Chapter 30. Of the Species of Animall, Brutes and Men 196
Chapter 31. Of the World 206
Appendix 213
INDEX 221

Charles Morton[1]

By Samuel Eliot Morison

IN the early part of the seventeenth century, a young gentleman from Quarrendon, Bucks, named Nicholas Morton, entered Emmanuel College, Cambridge.[2] There he obtained a scholarship, took his B.A. in 1615/16, obtained a Dixie fellowship, and commenced M.A. in 1619.[3] It seems probable that he retained his fellowship and residence until November, 1621, when he became rector of St. Ives in the Deanery of East Cornwall.[4] After living there some years he married, at Egloshayle, Frances, only daughter of Thomas Kestell of Pendavy, a Cornish squire.[5] Their first child, Charles Morton, was born at Pendavy, at the house of his maternal grandparents, and baptized at Egloshayle on February 15, 1626/27.[1]

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[1] There are notices of Morton in the *Dictionary of National Biography*, the *Dictionary of American Biography*, and Arnold G. Matthews, *Calamy Revised*. The earliest biography is in Edmund Calamy's "Account of Ministers Ejected" in his *Abridgment of Mr. Baxter's History of his Life and Times* (London, 1702; 2d ed., 1713). This is supplemented by Calamy's *Continuation of the Account of the Ministers Ejected* (London, 1727), and by Matthews' *Calamy Revised* (Oxford, 1934). No corpus of Morton letters has survived; but his MS. notebook, with records of ministers' meetings in Cornwall and New England, and a few letters are in the Massachusetts Historical Society. I have profited greatly by a MS. dissertation on Morton by Mr. Wilbur J. Bender, who wrote the notice in the *Dictionary of American Biography*.

[2] John and John A. Venn, *Alumni Cantabrigienses*, III. 218. Walter Wilson, the biographer of Defoe, has the best account of the Morton family (*Memoirs of the Life and Times of Daniel Defoe*, 1830 ed., I. 24 *n*). He says that the family originated in Nottinghamshire, and was the same as that of Cardinal Morton and Thomas Morton, Bishop of Durham. It appears to have had no connection with the Morton family of Yorkshire, who came early to Plymouth Colony.

[3] The aged Lawrence Chaderton was master of Emmanuel in his time, and Thomas Hooker a fellow. Among Morton's contemporaries as undergraduates were William Blackstone and Isaac Johnson, the founders of Boston, and Nathaniel Rogers and Samuel Whiting, the future ministers of Rowley and Lynn respectively; as well as Bastwick, the Puritan pamphleteer, and Samuel Clarke the martyrologist.

[4] George C. Boase, *Collectanea Cornubiensia*, p. 1402.

[5] The date of the marriage given by Venn, following Sir John MacLean, *Parochial and Family History of the Deanery of Trigg Minor* (I. 461), is May 11, 1616. It seems probable that the right date is 1626, and that the Mortons' first child was born nine months, not ten years and nine months, after their marriage. Nor is it likely that Morton would have resigned his fellowship at Emmanuel, immediately after taking his first degree, in order to marry.

A few months before this event Nicholas Morton had been promoted to the rectory of a large London parish: St. Saviour's, in Southwark (now Southwark Cathedral), very near the Surrey end of London Bridge. There, doubtless, the mother came to join her husband as soon as baby Charles was able to travel.

Among the few respectable families in the rather disreputable parish of St. Saviour's were the Harvards. And they were much fewer than they had been a few years before Morton came to Southwark. The plague of 1625 took Robert Harvard, a prosperous butcher and the head of the family, three of his sons, and two of his daughters, leaving only the mother and two sons, John and Thomas. The widow Harvard had already become Mrs. Elletson at the time Morton became rector, and upon Elletson's death after a six months' marriage, she took for third husband Richard Yearwood, grocer, of St. Saviour's parish.[2]

The new rector seems at once to have struck up a warm friendship with the surviving Harvards. Both he and his wife were named legatees in the wills of Thomas Harvard and Mrs. Yearwood; Morton was associated with John Harvard as executor of Thomas's will.[3] And as the Harvards had no previous university connections, one may assume that Morton was responsible for John's entering Emmanuel College, and that the two kept in close touch until John sailed for New England. It is a strange coincidence that Charles Morton, whom John Harvard must have seen as a baby, eventually became pastor of the church at Charlestown in the Massachusetts Bay where John was preaching at the time of his death on September 14, 1638.

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[1] Venn, *Alumni Cantabrigienses*, III. 217; *Dictionary of National Biography*, XXXIX. 149.

[2] For a succinct Harvard pedigree, see my *Founding of Harvard College*, p. 104.

[3] "I appoint my loveing frend Mr Moreton our minister of St Saviours aforesaid for one [of the overseers], and to him in token of my love I give three pounds and my paire of silver hafted knyves" (will of John Harvard's mother, 1635, in Henry F. Waters, *Genealogical Gleanings in England*, I. 125). "I give and bequeath unto Mr Nichollas Morton Minister and Preacher in the parishe of Saint Saviors in Southwarke the some of Forty shillinges in recompence of a Sermon which I desire he should preach at my funerall, for the better Comforte edifyinge and instruccion of such my freinds and neighboures and other people as there shalbe assembled" (will of John's brother Thomas, 1636, *id.*, p. 128).

Charles's mother died after bearing three more children: John, Nicholas, and a daughter.[1] Their father married for second wife Elizabeth King of Southwark. Nicholas Morton died in 1640, still "minister of the word of God at St Saviours, Southwark," leaving to each of his three sons "two pair of sheets" and an income of £30 a year from his estate during the widowhood of his second wife; at her death or marriage the estate was to be divided among his sons.[2]

Charles was now fourteen years old. It is probable that he and his younger brothers went to live with their grandfather or their uncle John Kestell at Pendavy,[3] since their residence is given as Egloshayle when they entered the universities. Cornish by birth, and half Cornish in blood, Charles looked the part: he and his brothers grew into "tall black men," typical Cornishmen.[4]

Apparently Charles encountered some difficulty in preparing for the university, since he was already twenty years old in 1646 when he entered Queen's College, Cambridge, as a pensioner. Cambridge was under Puritan control throughout the Great Rebellion; and Oxford, after serving as royalist capital, surrendered to Sir Thomas Fairfax in June, 1646. Parliament left the university to itself for almost a year. Twenty-four Visitors were then appointed to take measures to bring it in tune with the new régime. All the resources of delay, obstruction, and procrastination, in which men of learning are so rich, were eventually exhausted; and in March, 1647/48, the Visitors really got down to work. The salutary reforms that they effected in the university do not concern us here; for the main thing that affected Charles Morton was a general purgation of the colleges. Several hundred royalists—scholars, fellows, lecturers, professors, and heads of houses—who refused to submit to parliamentary authority, had to depart and yield their places to men faithful, at least outwardly, to the parliamentary government.[1] These "intruded" fellows, professors, and heads, as they were called, were in great part Cambridge Puritans who flocked in from the "less ancient and splendid institution" to enjoy the rich fruits of ancient foundations at Oxford. Not a few Harvard men shared in the bounty; two of the earliest being William Stoughton, the future lieutenant-governor of Massachusetts, who obtained a fellowship at New College in 1652, and Samuel Mather, chaplain of Magdalen College, whom Morton remembered thirty-five years later when writing to Samuel's brother Increase.[2]

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[1] John became rector of Auton-Gifford, Devon, and Nicholas followed his oldest brother to Wadham College, Oxford, and into the ministry.

[2] His will, dated 1640, is in Waters, *Genealogical Gleanings*, II. 782–783.

[3] Nicholas Morton in his will appoints his "living father in law Mr. Thomas Kestle of Plenderie" his executor; but MacLean (*Deanery of Trigg Minor*, I. 461) has Thomas Kestell buried in 1626, and succeeded as lord of the manor of Pendavy by his son John Kestell, Charles Morton's uncle.

[4] So Morton wrote to Increase Mather in 1685. Richard Frothingham, *History of Charlestown*, p. 195.

Among the "rude and pragmatical persons" (as Anthony Wood called them)[3] who swarmed into Oxford from Cambridge, was our Charles Morton. For why should he stay at Cambridge to take his degree when scholarships and fellowships at Oxford were going a-begging? We first find Morton in Oxford at New Inn Hall in 1648, when he made his formal submission to the Visitors.[4] On September 7, 1649, he was admitted a scholar at Wadham College, of which John Wilkins was the "intruded" warden.[5] He was allowed to count the terms he had kept at Cambridge toward the Bachelor of Arts degree, to which he was admitted on November 6, 1649. In 1652 he took his M.A. in course, and the next year was incorporated *ad eundem* in his original alma mater.[6]

As scholar of Wadham, Charles Morton's lot had fallen in pleasant places. Wadham College, built in 1610–1613, was one of the most modern and luxurious collegiate foundations in England; and it has remained almost unchanged in appearance to this day, save for the mark of age on the soft Headington stone of which it is built. Chambers and studies were more commodious than in the older colleges; the Hall was the second largest in Oxford; the chapel had the spaciousness of the great Somersetshire churches; kitchen and offices were ample. A formal garden, with walks radiating from a mound surmounted by a figure of Atlas holding a globe, separated the quadrangle from open country where the tiny Cherwell flowed between green fields to join the Isis. Indeed, so pleasant did Charles find Wadham that his younger brother Nicholas came there too, in 1650, and remained until 1656, until he had taken both degrees.

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[1] Sir Charles E. Mallet, *History of the University of Oxford*, II. 382–390; Montagu Burrows, *Register of the Visitors of the University of Oxford* (Camden Society), Introduction, *passim*.

[2] Frothingham, *Charlestown*, p. 195. Samuel Mather, elder brother of Increase, did not obtain an Oxford degree, as Cotton Mather relates; but the records of Magdalen College show that he was a chaplain there, *c* 1650–1653.

[3] Quoted by Mallet, *History of Oxford*, II. 383.

[4] Burrows, *Register*, p. 569.

[5] Robert B. Gardiner, *Registers of Wadham College*, Part I, p. 180.

[6] *Id.* His age is wrongly given in the records as nineteen.

If Morton's tastes were not scientific before he came to Oxford, he had come into the very milieu to turn them in that direction. For Oxford in the middle of the seventeenth century was much more friendly to experimental science—the "New Philosophy"—than Cambridge; and Wadham College was the scientific center of Oxford. Around 1645 the group of virtuosi known as the "Invisible College," which is generally regarded as the nucleus of the Royal Society, began holding meetings in London, one of their rules being that all subjects could be discussed but politics and religion. That was a difficult rule to maintain in the turbulent metropolis; and in 1648–1649, when new opportunities for income and leisure opened up at Oxford, most of the members shifted their residence to that university, and formed an "Oxford Philosophical Society."[1]

A mere list, as given here, of the prominent or promising scientists at Oxford in Morton's day, the "Oxonian Sparkles" who met either at Petty's lodgings or at the warden's lodgings at Wadham, will show the scientific influences to which Morton was exposed. Those with an asterisk prefixed were of the twelve who met at Gresham College on November 28, 1660, and formed the organization that obtained a charter in 1662 as the Royal Society for the Improvement of Natural Knowledge. Most of the others were elected fellows of the Royal Society at an early date.

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[1] MS. in British Museum by John Wallis. It is quoted in F. A. Dixey, *The Early Connexion of the Royal Society with Wadham College and the University of Oxford*, a pamphlet from which I have obtained most of the following data about this scientific group. Cf. Thomas Sprat, *History of the Royal Society* (1667); Irvine Masson, "The Genesis of the Royal Society," *Nature*, CXIII. 197–198; Dorothy Stimson, "Dr. Wilkins and the Royal Society," *Journal of Modern History*, III. 539–563. Dean Stimson, in a paper on "Puritanism and the New Science" read before the History of Science Society in 1934, showed that almost all members of this group were of Puritan training or antecedents. That made it easy for them to obtain professorial chairs and other appointments in the reformed Oxford.

*John Wilkins (1614–1672), author of *A Discourse tending to prove that tis probable our Earth is one of the Planets* (1640), and of *Mathematical Magick* (1648), was appointed warden of Wadham College by the parliamentary Visitors in 1648. He married a sister of Oliver Cromwell in 1651. Later he became Bishop of Chester.

Seth Ward (1617–1689), mathematical astronomer, followed Wilkins from London to Oxford and entered Wadham as a fellow-commoner. He lived in the chamber over the gateway at Wadham afterwards occupied by Christopher Wren.[1] In 1649, the same year that Ward took his M.A., he was appointed Savilian Professor of Astronomy.

John Wallis (1616–1703), mathematician, came to Oxford at the same time as Wilkins and in 1649 was appointed Savilian Professor of Geometry.

Thomas Willis (1621–1675), anatomist and physician, took his first medical degree at Oxford in 1646 and resided there through the Interregnum, constantly experimenting.

*Lawrence Rooke (1622–1662), astronomer, took his M.A. at Cambridge in 1647 and entered Wadham as a fellow-commoner in 1650. He left in 1652 to become professor of astronomy at Gresham College, London.

*Robert Boyle (1627–1691), the great chemist and philanthropist, settled at Oxford in 1654 and took charge of the Philosophical Society in 1659, when Wilkins left to be master of Trinity College, Cambridge.

*Sir William Petty (1623–1687), anatomist and economist, came to Oxford in 1648, took his M.D. the next year, and became fellow of Brasenose, deputy professor of anatomy, and, in 1651, professor of anatomy. He went to Ireland in 1652.

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[1] Joseph Wells, *Wadham College*, p. 75.

*Sir Christopher Wren (1632–1723), scientist and architect, entered Wadham College in 1649, the same year with Morton, and became fellow of All Souls on taking his M.A. in 1653.

*Jonathan Goddard (1617–1675), physician and maker of telescopes, was warden of Merton College, 1651–1660.

Thomas Sprat (1635–1713), historian of the Royal Society, entered Wadham in 1651, and took his M.A. in 1657.

Gilbert Ironside (1632–1701), second of the name to become Bishop of Bristol, entered as scholar of Wadham in 1650, and took his M.A. in 1653.

Walter Pope (*d* 1714), astronomer, was made a scholar of Wadham by the Visitors in 1648. He took his M.A. in 1652 and was a fellow of Wadham, 1651–1652. He was a half-brother of Warden Wilkins, and succeeded Rooke as professor of astronomy at Gresham College, being the third Wadham man in succession to hold the post.

Samuel Lee (1625–1691), a learned divine, "well acquainted with chemistry and physics," was fellow of Wadham, 1649–1657, and as bursar and sub-warden of the college brought its accounts into good shape. Cromwell made him minister of St. Botolph's, Bishopsgate. Lee and Morton were friends at Wadham—Wood mentions their sharing "an urne of coines" found in a wood near Stanton St. John[1]—and from 1678 Lee was minister of a Congregational church at Newington Green, and so neighbor of Morton. He sailed for New England in the same summer as Morton, though in a different ship, and became minister of Bristol, Rhode Island. Morton visited him there, but declined his invitation to preach to the "spiritual beares in Rhode Island"—the Baptists.[2] Lee made sage observations of political and natural phenomena in New England, which he communicated to his friend Dr. Nathaniel Grew.[3]

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[1] Andrew Clark, *Life and Times of Anthony Wood*, I. 265.

[2] 4 *Coll. Mass. Hist. Soc.*, VIII. 541–542.

[3] Printed, with notes by George Lyman Kittredge, in our *Publications*, XIV. 142–186.

Charles Morton's name is not found in the writings of the Wadham scientists, so far as I can discover; and he was not a member of their Oxford Philosophical Society or later a fellow of the Royal Society, although he contributed to their *Philosophical Transactions*[1] a short paper on "The Improvement of Cornwall by Sea-Sand." Edmund Calamy, the non-conformists' biographer, states that Morton was "extremely valued by Dr. Wilkins for his mathematical genius";[2] but as Calamy also makes Morton a fellow of Wadham, which the records show to be incorrect, we need not take this statement too seriously.[3] Still, in view of the close relationship that then existed between all members of a college, it seems hardly possible that a student in a small academic community of fifty or sixty members, where scientific tastes were encouraged by the authorities, can have failed to receive guidance and inspiration. Scientific enthusiasm ran so high at Wadham that it spread even to the servants. Christopher Brooke the manciple, whose ingenuity was encouraged by Warden Wilkins, invented a new quadrant![4]

How long Charles Morton remained in residence at Wadham is not known. Possibly he was still there in July, 1654, when John Evelyn visited Oxford; "supped at a magnificent entertainment in Wadham Hall, invited by my dear and excellent friend Dr. Wilkins"; met "that miracle of a youth Mr. Christopher Wren"; and, later, "dined with that most obliging and universally-curious Dr. Wilkins at Wadham College," by whom he was shown a variety of "dials, perspectives, and many other artificial, mathematical, and magical curiosities, a way-wiser, a thermometer, a monstrous magnet, conic and other sections, a balance on a demi-circle; most of them his own. . . ."[5]

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[1] Volume x (1676), pp. 293–296.

[2] *Nonconformist's Memorial*, I. 347; see also Matthews, *Calamy Revised*, pp. 356–357.

[3] Calamy also states that Morton was converted to Puritanism at Oxford. It is unlikely that he would have come to Oxford in 1648, or taken up residence in a Hall already noted for Puritanism, if he had not already come around to that point of view. His father, describing himself in his will as "minister of God's Word" rather than "rector," showed himself at least a moderate Puritan; but his Cornish grandparents may well have been Church-and-King men.

[4] Wells, *Wadham College*, pp. 78–79.

[5] John Evelyn, *Diary* (Bohn ed., 1889), I. 305–308.

But Morton was probably absent on that interesting occasion; for his latest biographer believes that he is identical with the Charles Morton who was vicar of Takeley, Essex, in February, 1652/53.[1] The Church of England at this time was Presbyterian, and Morton, as a recent Oxford M.A. and a Puritan, was a likely candidate for an ecclesiastical living.

If our Morton was identical with the Charles Morton who was vicar of Takeley, he did not remain there long; for in 1655 the Presbyterian party in the parish of Blisland, Cornwall, ejected the then incumbent, and installed Charles Morton. Blisland was only six or seven miles from Pendavy, the seat of the Kestells, where Morton had spent part of his childhood. At the restoration of the monarchy in 1660, these Blisland proceedings were naturally declared void, and a new rector was installed.[2]

For a time Morton lived at St. Ives, where his father had been rector, in a small tenement of his own, and preached privately to a few people from a neighboring village until 1666. Losses from the Great Fire of London then made it expedient that he move thither in order to take care of his property.[3]

During the next nine years there is but one trace of Morton's movements. On April 12, 1672, he was licensed to preach at his home in Kennington, a suburb of London.[4] This meant that he was acting pastor to a small neighborhood church of dissenters, as the old Puritans and others were called who refused conformity to the restored Anglican Church.

At this period the dissenters were setting up academies of higher learning where their sons, excluded from the universities by the Test Acts, could have an education of university grade. "About 1675"[5] Morton opened an academy in a well-appointed house at Newington Green, in Stoke Newington, a suburb of London.

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[1] Matthews, *Calamy Revised*, p. 356, quoting Lambeth Palace Library MSS.

[2] *Complete Parochial History of Cornwall*, I. 67; MacLean, *Deanery of Trigg Minor*, I. 53.

[3] Calamy, *Nonconformist's Memorial*, I. 348.

[4] Matthews, *Calamy Revised*, p. 356.

[5] Herbert McLachlan, *English Education under the Test Acts*, p. 76. This is the best work on the dissenting academies. See also Irene Parker, *Dissenting Academies in England*, pp. 45–63. There were two academies at Newington Green. The first was kept by Theophilus Gale, ejected fellow of Magdalen College, Oxford, later a benefactor of the Harvard College Library.

These dissenting academies, starting free from the trammels of obsolete statutes and ancient usage, were the most advanced schools of higher learning in England. They introduced the study of modern languages and gave more attention to natural science than did the universities.

Morton's Newington Green academy was reckoned one of the best, if not the best, in England; and something more is known about it because two of Morton's pupils, Samuel Wesley and Daniel Defoe, became famous. Both men in their writings praised Morton and the academy. Other pupils of Morton whose names are to be found in the *Dictionary of National Biography* are Timothy Cruso, the "golden preacher of Crutched Friars," and John Shower, pastor at Old Jewry.[1]

Newington Green was the central square of an ancient village called Stoke Newington, between Highbury and Hackney. London has long since spread out and engulfed the region; but in Morton's time it was a rural neighborhood, with many gentlemen's country estates nearby. Wesley says that the Newington Green academy had "a fine Garden, Bowling Green, Fish-pond, and within a Laboratory, and some not inconsiderable Rarities with Air Pumps, thermometers, and all sorts of Mathematical Instruments."[2] There were about fifty students in the academy in his day, including even a few of the nobility, but on the whole, according to Wesley, rather a "republican" lot. The future rector of Epworth was shocked when a gang of his schoolmates tried out one of Master Morton's pieces of apparatus, a speaking trumpet, bellowing forth insults to the local Anglican clergyman from a neighboring hill.

Wesley has recorded part of a doggerel rhyme that he made up of the names of some of the books that he had to study, most of which were read by Harvard students at the same period:

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[1] Luke Tyerman, *Life and Times of the Rev. Samuel Wesley*, p. 74.

[2] *A Letter from a Country Divine to His Friend in London, Concerning the Education of the Dissenters, in their Private Academies* (London, 1703), pp. 7–8.

Sthalius, et Suarez, Gassendus cum Zabarella,
  Et Keckermannus, tuque Hereborde Pater!
Hisce Opus immortale tuum, Venerande Cracanthorp!
  Scheiblerique ingens, Smiglecijque Labor.
Carolus et Morton; Mortonius inclytus, et Tu,
  Carole! etc.[1]

Daniel Defoe complained that he missed at Newington Green the witty conversation of the universities, but he praised Morton for conducting scholastic exercises in English, and training the students in the use of their mother tongue. Another method of which Morton made great use was compiling "systems" of various arts and sciences, which his pupils copied for their own use as text-books. These, says Calamy, were "always brief and compendious," Morton "being a declar'd Enemy to large Volumes; as he signified by that Saying which was often in his Mouth, Μεγὰ βιβλίον μεγὰ κακὸν—A great Book is a great Evil."[2] Defoe as late as 1704 preserved Morton's system of "Politicks" and a "Manuscript of Science" which can have been none other than our *Compendium Physicae*.[3]

As an instance of Morton's liberalism, it may be noted that he had his ministerial pupils read some of the works of John Biddle, the first English Unitarian, who was regarded as a sort of antichrist by Anglicans and dissenters alike. Young Samuel Wesley was set to translate some of Biddle's Latin works. His pious nineteenth-century biographer thought it very fortunate that Wesley was not ruined by these "pernicious writings," and became the founder of Methodism instead of a "cold-hearted sceptic."[1]

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[1] *A Defence of a Letter concerning the Education of Dissenters in their Private Academies* (1704), pp. 44, 51. Other references to Morton and his academy will be found in the same tract, pp. 4, 14, 27, 43, 44, 48 (pupils going to hear Bunyan preach, and Morton commending him), 53.

[2] *Continuation*, I. 211, where a list of Morton's published pamphlets and manuscript treatises is given. Calamy reprints Morton's MS. "Advice to Candidates for the Ministry" on pp. 198–210. It is full of wit and common sense: "Let your Discourses be mostly Practical, both as to the Subjects, and Manner of Handling. 'Tis but a Crack, for young Divines to be much medling with Controversies. Wrangling Divinity will but put your Spirits out of the comely Christian Frame. . . ."

[3] Defoe, "More Short Ways with the Dissenters" (1704), as reprinted in his *Collection of Writings* (1703–1705), II. 276. Samuel Palmer, *Vindication of the Learning of the Dissenters* (1705), pp. 53–54, and Joshua Toulmin, *Historical View of the State of the Protestant Dissenters* (1814), p. 233, say that the system of Politics called *Eutaxia*, modelled on More's *Utopia*, was "equal, if not superior, to any printed composition of that kind." No copy of it is now known to exist.

By one of the dissenters' historians Morton is described as a natural teacher, "a pious, learned and ingenious man, of a sweet natural temper and a generous public spirit, beloved and valued by all that knew him,"[2] caring nothing for fame or money, only wishing to be allowed to teach quietly. This he was not long permitted to do. The dissenting academies were soon to suffer persecution from the authorities, egged on by the jealous universities. Masters and tutors like Morton who were graduates of Oxford and Cambridge were held by churchmen to have violated the so-called "Stamford Oath," which they took on commencing M.A., never to teach in any university except Oxford or Cambridge;[3] and efforts were made to inflict the pains and penalties of perjury on them for a technical violation of an academic oath which had been regarded as a joke for three centuries. Local magistrates, eager to curry favor with the government, harassed the dissenting academies for petty violations of the law; spite suits and all the means of persecution that a dominant group has at its disposal to molest an unpopular minority were used to discourage these excellent institutions of learning. Edward Veel, sometime student of Christ Church and fellow of Trinity College, Dublin, was so harassed by the authorities that he gave up his academy at Stepney in 1680; Morton held out five years longer. He was excommunicated, apprehended on a capias, and placed in custody, from which he escaped through the death of the officer in charge of him.[4] He made an excellent defense against violating the oath, pointing out that the Church had never objected to Oxford graduates lecturing in houses of the nobility, or publicly at Gresham College; and that the dissenting academies pretended to none of the privileges of universities, such as conferring degrees.[1] The protection of powerful friends obtained him a certain respite; but at length he became "so infested with Processes from the Bishops Court" that when a new opportunity arose for usefulness overseas, he embraced it eagerly and sailed for New England. Had he held out two years more, the Declaration of Indulgence of James II (1687) would have protected him and given the Newington Green academy a new lease of life.[2]

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[1] Tyerman, *Life of Samuel Wesley*, pp. 71–72.

[2] Toulmin, *Historical View of the Dissenters*, p. 234.

[3] McLachlan, *English Education under the Test Acts*, pp. 2, 76; text in Calamy, *Continuation*, I. 177. This was not one of the Test Oaths. It had been instituted in the fourteenth century to force the seceding scholars at Stamford to return to England. Dean Peacock, in his *Observations on the Statutes of the University of Cambridge* (1841), remarked that it had been consistently violated from the time of its imposition to his own day.

[4] Samuel Wesley, *Defence of a Letter*, p. 53; Tyerman, *Life of Samuel Wesley*, p. 67.

The First Church in Charlestown, one of the oldest churches in the Bay Colony, was without a pastor in 1685 because of the death of Thomas Shepard, third of that name. The church decided to give Charles Morton a tentative call; and on August 4 Increase Mather, on the strength of having met Morton on a journey from the West Country to London many years before, wrote him in England, enclosing an invitation from Samuel Nowell of Charlestown. From the tenor of Morton's reply, it seems that Mather also intimated that the Harvard presidency was vacant. That important office had been going begging ever since President Hoar had been driven out of it by a tutor-and-student strike in 1675. Urian Oakes had been prevailed upon to take it after long holding back; but he died in 1681. John Rogers took it the next year, and died in 1684. After a year's vacancy and several offers and refusals, Increase Mather consented to act as president *pro tempore* in June, 1685, but continued to reside in Boston and minister to his church there. The college was in a "low and languishing state" with a mere handful of students, and much wanted the invigoration of a good scholar and administrator who would give his undivided attention to the job.

Morton replied to Mather on October 10, 1685, that he was ready to serve God in New England in any capacity he might; and that as a pledge of good will he was sending out as bearer of the letter his nephew Nicholas Morton to finish his education at Harvard College.[1] It was some months before Charles Morton (now turned sixty) could put his affairs in order, wind up the Newington Green academy, and leave for New England; but he was ready to sail in April, 1686, and arrived at Boston about the first day of June.[2] With him were his wife, his daughter Mary, his nephew Charles (a physician), and a young disciple, Samuel Penhallow, who had an appointment from the New England Company to do missionary work among the Indians. John Dunton, the Boston bookseller, writes that "the News of his Arrival was received here with Extraordinary Joy by the People in general."[3]

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[1] Printed in Calamy, *Continuation*, I. 177–197.

[2] McLachlan, *English Education under the Test Acts*, p. 65. Other academies were founded by Presbyterian, Congregational, and Baptist societies in the following century. The most famous of these was Warrington Academy, "The Athens of the North," where Priestley taught. See John F. Fulton, "The Warrington Academy and its Influence upon Medicine and Science," *Bulletin of the Institute of the History of Medicine* (Johns Hopkins University), I. 50–80.

Henry Horsey of Newington Green (from whose letter we glean these facts), and Penhallow in his autobiography[4] agree that Morton came over with the Harvard presidency "in prospect"; and so Edward Randolph wrote home from Boston.[5] Horsey added that William Stoughton and Joseph Dudley knew Morton well. The first, as has been seen, may have been an Oxford friend; and both had probably seen much of him on their missions to England, for Massachusetts delegates were always well received and entertained by their dissenting brethren in the Old Country.

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[1] Prince MSS., Mass. Hist. Soc.; printed in Frothingham, *Charlestown*, p. 195.

[2] Edward Randolph, in a letter dated July 28, to the Lords of Trade (*Hutchinson Papers*, Prince Society, II. 287), and in another, dated August 2, to Archbishop Sancroft (*N. E. Hist. Gen. Register*, XXXVII. 271), says that Morton arrived "about 2 months agoe." Samuel Sewall first mentions Morton when Morton was giving the weekly lecture in Cambridge meeting on July 21 (*Diary*, I. 144–145).

[3] John Dunton, *Letters from New England* (Prince Society), p. 296. Both here and in his *Life and Errors* (1818 ed., I. 123), Dunton makes an elaborate and complimentary characterization of Morton. Dunton certainly knew Morton, who asked Increase Mather to be kind to the young bookseller, and who had taught Dunton's uncle, the Reverend Obadiah Marriott. But Dunton's characterizations are so frequently lifted from other books, as Chester N. Greenough has shown (our *Publications*, XIV. 212–257; XXI. 232–251), that I have not seen fit to quote him further.

[4] Henry Horsey to his brother in New England, Prince MSS., Mass. Hist. Soc.; printed in William I. Budington, *History of the First Church, Charlestown*, p. 221; extract from Penhallow's autobiography in 2 *Coll. Mass. Hist. Soc.*, I. 161.

[5] *Hutchinson Papers*, II. 287, 293.

During the twelve months that elapsed between Mather's invitation and Morton's arrival, the posture of affairs in New England had changed. The Massachusetts Bay charter had been vacated, and it was assumed that the college charter went with it: "the calf died in the cow's belly," as it was bluntly said. Massachusetts Bay was combined with other colonies as the Dominion of New England, and ruled over by a royal governor and council. Joseph Dudley took office at Boston on May 25, 1686, as president of the Council for New England. In that juncture it would have been unwise for the Harvard Corporation to attempt the choice of a president, and presumptuous folly to elect a person so decidedly *non grata* to the king. President Dudley and his council dealt with the situation themselves by ordering (July 23, 1686) Increase Mather to continue as head of the college with the title of rector. So Morton accepted the call to the church of Charlestown, and was installed as pastor on November 5, 1686. Increase Mather and Joshua Moody, who officiated on that occasion, and Judge Sewall, who was present—as on all such occasions—took it ill that Morton refused to let the attendant clerics "lay hands" on him after the New England fashion; and said so bluntly.[1] But Morton conformed in all essentials to the New England way, and had a most successful ministry of twelve years, in which there were 623 baptisms and 59 admissions to full communion.[2]

Thus, after almost fifty years, the old neighborhood association of the Harvards and the Mortons was renewed. Charles Morton, son of John Harvard's patron and rector, was now pastor of John Harvard's church. He did not, however, live in John Harvard's old house, which was occupied by the widow of the previous pastor, Thomas Shepard.[3] Morton, who seems to have been comfortably well off at all periods of his life, built himself a new parsonage. In October, 1691, Judge Sewall dined there with Mr. and Mrs. Morton shortly after they had moved in. At the table were the Reverend and Mrs. Joshua Moody, the Reverend James Allen (a contemporary of Morton at Oxford), the Reverend John Bailey and his son, and Lady Phips.[1]

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[1] Sewall, *Diary*, I. 155. The issue was that Morton had already been ordained in England and so refused to be ordained again, insisting on being merely "installed." He set a precedent since followed in New England Congregational churches.

[2] Budington, *First Church, Charlestown*, pp. 103, 106–113.

[3] Sewall, *Diary*, I. 446–447.

Morton seemed to fit himself in snugly with his New England neighbors. Edward Randolph considered him one of the "faction" or gang who refused complete submission to the new royal government of Andros. In a memorable sermon preached in September, 1687, Morton assured the people of Charlestown that "the rulers of Jerusalem were unjustly set aside," the old colony charter was still valid, and "it would not be long before God restored their ancient Magistrates."[2] In consequence he was ordered by the council to attend and answer for "seditious expressions and a seditious sermon," and bound over in £500 to take his trial at the next Superior Court.[3] The trial was held in Boston because the authorities believed that, as they expressed it, "there were not honest men enough in Middlesex" to put Mr. Morton away. Nevertheless, the Boston jury acquitted him of sedition, to the great delight of those whom Randolph called the "factious rabble."[4] On Morton the effect was to enhance his popularity, and to identify him completely with this transatlantic community that he had joined so late in life.

It was perhaps fortunate that Morton did not obtain the college presidency. Eminently qualified as he was, in learning, by experience, and by reason of his "excellent sweet natural temper" and "loving and generous spirit,"[5] he might have found the college a cross, not a crown to his career. The last imported president, Leonard Hoar, who dreamed of making Harvard the New-World home of experimental science, found the Harvard students impossible to manage. Harvard was in good hands under two able young tutors, John Leverett and William Brattle (Mather being largely a figurehead and long absent in England). Through his *Compendium Physicae* and his residence at Charlestown, where he could always be consulted on scientific and theological topics, Morton became a great and salutary influence on the college without having the burden and vexation of the presidency.

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[1] Sewall, *Diary*, I. 349.

[2] John G. Palfrey, *History of New England* (1890 ed.), III. 549; *Calendar of State Papers, Colonial, Am. and W. I.*, 1689–1692, p. 165.

[3] *Calendar of State Papers, Colonial, Am. and W. I.*, 1685–1688, pp. 470–471.

[4] Frothingham, *Charlestown*, pp. 221–223.

[5] Horsey's letter in Budington, *First Church, Charlestown*, p. 221.

Morton had brought over a set of his manuscript outlines with him,[1] and the *Compendium Physicae* seems to have been adopted at Harvard shortly after his arrival. The title page of one of the earliest copies contains the date 1687, and the *theses physicae* on the Harvard Commencement broadside that year prove that the *Compendium* had already affected the scientific outlook at Harvard for the better. Of the thirty-seven *theses physicae* in 1687—eight of them marked for debate—several can be traced directly to Morton's *Compendium*:

> Gravitas est vix attractrix terrae.
>
> Radii luminosi sunt corporei.

From the same source are several of the others:

> Corpora densa lucem reddunt, minus densa imbibunt.
>
> Generatio est principium Corruptionis.
>
> Pisces respirant per attractionem & remissionem aeris.
>
> Sonus nihil aliud est, nisi motus corporis realis.

From this time on, the modern note prevails in Harvard Commencement *theses physicae*; they deal with heat, light, motion, gravity, magnetism, the conservation of matter, mechanics, and other topics of experimental science. Morton's *Compendium* was copied and recopied by students; it is found in the programme of studies in 1723; and several copies are found with marks of Harvard and Yale ownership at an even later date. With Morton's help, Harvard College pulled out of the bog of medieval science, and set her face toward experimental philosophy and the "century of enlightenment."

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[1] So says John Dunton, 2 *Coll. Mass. Hist. Soc.*, I. 115–116.

Morton had too much of the teacher's instinct to confine himself to the pastoral office. Penhallow and Morton's nephew Charles, instead of enrolling at Harvard, continued under Morton's tutelage; and these private "philosophical lectures" in the Charlestown parsonage almost led to the establishment of another private academy. "Several from the College" came to hear his lectures. But Morton soon discovered that Harvard was quite as jealous of his competition as Oxford had been. In December, 1686, after John Emerson of the sophomore class had been punished for negligence in studies, his father removed him to Mr. Morton's. Rector Mather and the Harvard tutors then addressed a sharp letter to Morton, declaring that it would be "very offensive" to them, and "no small reflection" on him if he should "enterteyn" such students. Morton, in his kindly way, took the hint, and received no more Harvard students.[1]

In the successive imperfect charters under which Harvard College was governed from 1692 to 1700, Morton was either a fellow or vice-president. As fellow of the Corporation under the charter of 1692, he attended every meeting but three. He was named vice-president in the charter of 1696, which the Corporation rejected; and he was named vice-president in the charter of 1697, but, doubtless from declining health, attended but one meeting.[2] The only action associated with his name in the college records was the introduction at the Corporation meeting of October 2, 1693, of a discussion on the question, "How may the Colledge be made greater and better?" After his proposals had been read and considered, Morton, Leverett, and Brattle were appointed a committee "to make A Model, and to draw up Som proposalls for the Enlargment of the Colledge by new buildings."[3] Their report has not been found; not improbably it started the movement which resulted in the building of Stoughton College in 1699 as a gift of Morton's old friend, William Stoughton.

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[1] 2 *Coll. Mass. Hist. Soc.*, I. 162; 4 *Coll. Mass. Hist. Soc.*, VIII. 111–112.

[2] Our *Publications*, XV. cxlix, xliii *n*, cl.

[3] *Id.*, p. 345.

This movement for a bigger and better Harvard had already been debated at the Cambridge Ministerial Association which Morton had founded, and of which he was one of the leading spirits. Over thirty years before, as vicar of Blisland in Cornwall, he had been secretary of an association of Cornish ministers. The book of records, ending in 1659, Morton brought over with him to Charlestown, and as the greater part of the pages were still blank, he used them for the records of the Cambridge Ministerial Association, which he organized at Charlestown on October 13, 1690. It included all the ministers of Boston and the neighboring towns. They met at the college about every six weeks and discussed matters of ecclesiastical and general public interest.[1]

Morton appears to have seen eye-to-eye with his New England colleagues on all questions, including the momentous one of witchcraft that flared up in 1692. His ideas on witchcraft did not differ from those of other educated men in England of his day and generation; he doubted not its existence; he believed that people could confederate with the Devil, and in so doing justly incurred the penalty of death; but he thought that judicial processes for the detecting of witchcraft should be conducted with great care. Since the appearance of Professor Kittredge's book, it is no longer necessary to argue that a man of learning, cognizant of the new experimental philosophy, could take this attitude honestly and (so far as he himself could judge) consistently. Witchcraft was a phenomenon, like the phenomena of motion, heat, and light, which should not be ignored, but must be faced and investigated. The evidence of its existence was quite as strong (so far as men of that time could judge) as that for planetary motion or the molecular structure of matter. It is difficult, with our modern prepossessions, to avoid the feeling that Morton, as an English schoolmaster in touch with the latest scientific developments, should have quenched the superstitious zeal of his "bigoted" New England brethren with the cold water of scientific scepticism. Actually, the converse is true. Robert Boyle, and doubtless most of the old scientific group at Wadham College, believed in witchcraft;[1] and the man responsible for the revival in witchcraft literature near the end of the century was a fellow of the Royal Society, Joseph Glanvil. His *Sadducismus Triumphatus* (1681) "was thought to have put the belief in apparitions and witchcraft on an unshakable basis of science and philosophy."[2] Indeed it was the people who composed what one might call the Cambridge Scientific Club of that day—Morton, Willard, Stoughton, and the Mathers—who took the keenest interest in witchcraft. If the Boston and Salem clergy had been more old-fashioned and less curious respecting phenomena, we might never have had the hangings of 1692. The fatal expansion of a neighborhood quarrel into a popular panic occurred when the "afflicted" girls of Salem Village discovered that their antics obtained attention and publicity for themselves from the leading intellectuals of the province.[3]

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[1] The record book, which after Morton's death belonged to the Rogers family of Ipswich, is now in the Massachusetts Historical Society. It is printed in 1 *Proc. Mass. Hist. Soc.*, XVII. 254–280. Cotton Mather printed some of the conclusions arrived at by the Association as *Thirty Important Cases* (Boston, 1699), and reprinted it as Book V of the *Magnalia Christi Americana* (1702).

The prelude to the Salem frenzy was the Goodwin witchcraft case in Boston in 1688. Morton was one of the five or six ministers who concerned themselves with curing the afflicted children by fasting and prayer;[4] and he was one of the four who signed the preface to Cotton Mather's *Memorable Providences Relating to Witchcraft* (Boston, 1689), which described the Goodwin case and others.[5] Although no causal connection between this tract and the Salem Village outbreak of 1692 can be proved, there is some reason to suspect that Ann Putnam and the other young exhibitionists who started the trouble in Essex County had heard the Goodwin case talked about, and that the Reverend Samuel Parris, whose bungling handling of the case contributed greatly to its spread, supposed that he was playing the rôle of exorcist that had been successfully assumed in Boston by Cotton Mather, Willard, Moody, and Morton. In the Salem frenzy, Morton seems to have played a quiescent or discreet part. If he attempted to restrain the intemperate zeal of his old friend Stoughton, the presiding justice, it is not on record; but he did share in Increase Mather's successful, if somewhat belated, effort to apply the brakes. On August 1, 1692, after six women had been hanged as witches, the Cambridge Ministerial Association debated the question of "spectral evidence," largely upon which the unfortunate women were condemned; and voted against its use except as corroborative evidence. In their belief the Devil could so possess one of his victims as to accuse a totally innocent person of tormenting the victim.[1] A little quick action to impress that doctrine on the Salem court would have saved much innocent blood; but the pack was now howling after victims, and even ministers had to watch their steps very carefully in order not to find themselves on the path that led up Gallows Hill.

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[1] George L. Kittredge, *Witchcraft in Old and New England*, p. 336.

[2] *Id.*, p. 335.

[3] See Edward Wyllys Taylor, "Some Medical Aspects of Witchcraft," in *Problems of Personality* (the nearest to a rational explanation of the frenzy that we have), and Charles W. Upham, *Salem Witchcraft*, II. 112.

[4] 4 *Coll. Mass. Hist. Soc.*, VIII. 368; *Magnalia* (1853 ed.), II. 457, 463, 465.

[5] George L. Burr, Editor, *Narratives of the Witchcraft Cases*, p. 97.

As a result of the ministerial meeting of August 1, Increase Mather wrote *Cases of Conscience Concerning Evil Spirits*, which was read and endorsed by the Ministerial Association on October 3,[2] promptly laid before Governor Phips, and printed before the end of the year. This tract had a strong, if not a decisive, influence in inducing Governor Phips to put a stop to the proceedings. The special court met again in January, 1693, but without the use of spectral evidence all the prosecutions failed, and the frenzy subsided.[3]

One would suppose that after the witchcraft fever had run its course, the more enlightened men in the community would have let the supernatural alone, at least for a time. On the contrary, the Cambridge Ministers' Association, in the winter of 1693–1694, issued a new set of "Proposals for the Recording of Illustrious Providences."[1] Although this seems to have been a particular pet of the Mathers, Morton, Leverett, and Brattle signed it, and the "Proposals" went out to the ministers of New England as from the Harvard Corporation.

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[1] 1 *Proc. Mass. Hist. Soc.*, XVII. 268.

[2] *Id.*

[3] See Thomas J. Holmes's able and detailed discussion of Increase Mather's *Cases of Conscience* and its influence in his *Increase Mather, A Bibliography of His Works*, I. 117–138.

Ten years before, Increase Mather had expressed the hope that a natural history of New England might be written "according to the rules and method" described by Robert Boyle.[2] The Royal Society was keen to get weather reports, bills of mortality, and data on fauna and flora from New England. Yet these "Proposals" of 1694 are little more than an invitation to gather ghost stories and accounts of violent intervention of Divine Providence in the universe. It is to the credit of the ministers of New England that very few paid any attention to this ancestor of the questionnaires that clog our mail nowadays.

Charles Morton was named vice-president of Harvard College in the draft charter passed by the General Court on June 4, 1697.[3] He was present at the first meeting of the new Harvard Corporation on July 13; but was unable to attend again. Judge Sewall had already noted Morton's shortness of breath at the funeral of Thomas Graves, on June 1—he sat, panting, on a tomb in the old Charlestown burying place, and "said, for ought he knew, he should be next."[4] The following January he took to his bed and never left it alive. The mildly macabre details of his death on April 11, 1698, are recorded by Sewall in his diary, where they may be read by the curious.[5] The funeral on April 14 was attended by Lieutenant-Governor Stoughton and about twelve councillors; scholars of Harvard College preceded the hearse to the burying-ground, and the pall-bearers were President Mather and five other ministers.

Simon Bradstreet, Morton's successor in the Charlestown pulpit, composed a Latin inscription and epitaph[6] for him, which was preserved in writing as a good specimen of New England Latin epigraphy long after the tombstone had disappeared. His will left £50 to Harvard College and the rest of his estate in Charlestown and in Cornwall to his nephews Charles and John and his niece Mary Morton.[1]

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[1] 1 *Proc. Mass. Hist. Soc.*, XVII. 271; *Magnalia*, Book v.

[2] Preface to Increase Mather, *An Essay for the Recording of Illustrious Providences* (Boston, 1684).

[3] Our *Publications*, XV. xlvii, cl.

[4] *Diary*, I. 468.

[5] *Id.*, I. 471.

[6] 1 *Coll. Mass. Hist. Soc.*, VIII. 76.

SACRÆ & SEMPITERNÆ MEMORIÆ
REVERENDI PLURIMÙM ET CLARISSIMI VIRI
DOM. CAROLI MORTONI,
ECCLESIÆ CHARLESTONIENSIS PASTORIS INSTRUCTISSIMI:
NEC NON COLLEGII HARVARDINI VICE PRÆSID. PRIMI ÆQUE AC
INSIGNITER IN OMNI
LITERARUM GENERE VERSATIL,
VIRI DENIQUE; TUM IN ANGLIA, (UBI NATUS FUIT ET MAXIMÈ
FLORUIT) TUM IN NOV-ANGLIA
(UBI SENILIS OBIIT) PERMULTIS NOMINIBUS CELEBRANDI.
QUI VITA HAC ÆRUMNOSÂ PROBÈ DEFUNCTUS, APRIL DIE XI.
ANNO D. MDCXCVIII
ÆTATIS SUÆ LXXII
EX PARTE SUI IMMORTALI AC NOBILISSIMÂ IN CÆLIS TRIUMPHAT: EX ALTERA VERÒ, CORRUPTIBILI SCILICET, IN HOC MONUMENTO PAULISPER QUIESCIT; EXPECTANS DUM VOCEM AUDIERIT FILII DEI, QUA REVOCATUS A MORTE IN VITAM VERÈ VITALEM QUAM GLORIOSUS IN ETERNUM REGNABIT.

EPITAPHIUM

INCLYTA *MORTONUS* MUSARUM GLORIA QUONDAM
ET SACER ETERNI REGIS LEGATUS JESU
POST VARIOS CASUS, POST FUNERA MULTA SUORUM
SIC CADIT IN CINERES RESOLUTUS AB HOSTE SUPREMO,
UT DOMINI VIRTUTE SUI VICTRICE RESURGENS
GAUDEAT ÆTERNIS, ABSORPTA MORTE, TRIUMPHIS.

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[1] Thomas B. Wyman, *Genealogies and Estates of Charlestown*, pp. 687–688. Mrs. Morton, of whom nothing seems to have been known except her first name, Joan, had died in 1693, and his nephew Nicholas died soon after graduating from Harvard. No children are mentioned in the will.

The *Compendium Physicae*

An Introduction by Theodore Hornberger

CHARLES Morton's *Compendium Physicae*, here printed for the first time, is the text-book in science which was used by Harvard College students during most of the forty years between 1687 and 1728. As Mr. Morison has shown,[1] it was probably compiled by Morton about 1680, brought with him from England in 1686, and adopted at Harvard in time to have visible effects upon the Commencement *theses* of 1687. A fairly safe presumption is that it was not entirely superseded until 1728, when Isaac Greenwood became the first Hollis Professor of Mathematics and Natural Philosophy.

Greenwood's approach to scientific studies, considerably different from Morton's, was acquired in London under the tutelage of such teachers as John Theophilus Desaguliers, one of the first popularizers of Sir Isaac Newton's discoveries and theories. The new technique may be observed in Greenwood's prospectus, *An Experimental Course on Mechanical Philosophy* (Boston, 1726), and in the use at Harvard, after 1728, of Thomas Hollis's gift of a "fine Apparatus for Experimental Philosophy." That gift, which followed the foundation of the professorship, included "machines for experiments of falling bodies, of the centre of gravity, and of centrifugal forces," "very nice balances," siphons, "tubes for the Torricellian experiment," a "large, double-barrelled Air-Pump," mirrors ("concave, convex, cylindric"), lenses, prisms, and "the whole apparatus for the Newtonian theory of light and colors."[2]

The arrival of this apparatus is a landmark in the history of the teaching of science in America. Yet Morton's *Compendium*, as he who reads it will discover, pointed out the importance of experimental methods, described many of them, and gave Harvard students at least a glimpse of the so-called "New Science" when that amazing expansion of the European mind had attracted the attention of but few university men.

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[1] *Harvard College in the Seventeenth Century*, pp. 236–251.

[2] Josiah Quincy, *History of Harvard University*, II. 482–483.

Mr. Morison, in his foreword, has told of Morton's eventful life; his *Harvard College in the Seventeenth Century* contains the only study made heretofore of the significance and most important origins of the *Compendium*. There remain but two tasks: to describe the manuscripts which have, after two centuries, come to seem worth printing as a revelation of colonial intellectual life and the transfer of ideas from Europe to America; and to make some additional comment upon the potpourri of ancient and modern ideas which this book presents to the reader interested in the history of science and learning.

The original syllabus which Morton is believed to have prepared for his lectures, and which he must have deposited in the library or some other place convenient for student copyists, can not now be located. It is possible that it may some day be found, but very likely it was destroyed (along with the Hollis apparatus and most of the college library) when Harvard Hall burned in 1764.

Any hope for its eventual discovery rests upon Morton's will, which assigned to Harvard College the sum of fifty pounds, but gave to his executor the power to dispose of "all his philosophical writings, sermon notes, pamphlets, mathematical instruments and other rarities." In 1859 William B. Sprague stated that two of Morton's manuscripts were still preserved: one, with a Latin title, in the library of the American Antiquarian Society, the other, with the title in English, at Bowdoin College.[1] The Antiquarian Society now possesses two transcriptions of the *Compendium*; but that with a Latin title lacks many of the diagrams and otherwise shows evidence of being a copy, although the copyist and the date are unknown. Bowdoin College has no record of ever having owned any Morton papers, though Sprague's statement is repeated in the notice of Morton in the *Dictionary of American Biography*. The Massachusetts Historical Society, however, has a transcription by Jeremy

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[1] *Annals of the American Pulpit*, I. 218.

Gridley which was presented to it in 1817 by Professor Parker Cleaveland of Bowdoin. It seems likely that Gridley's copy is the Bowdoin manuscript which Sprague had heard about.

It is possible, moreover, that there are in existence other transcriptions than those listed below, although my own search has been supplemented by investigations of Mr. Morison and of Arthur O. Norton, who has recently published the result of his twenty-year hunt for seventeenth-century Harvard text-books.[1] Thus far there are thirteen known copies of Morton's manuscript. They are listed here in chronological order.[2]

1680

Bodleian MS., Bodleian Library. (6) 292 pages, with synopses at the end of each chapter. It lacks, however, the mnemonic verses which are in the fuller American transcriptions, and is obviously a copy of an earlier manuscript than that used at Harvard. It was perhaps made by Bartholomew Beale, son of Mary Beale, a popular portrait painter.[3] It is dated at the end: "Finitum. 29 Martij 1680."

1688

Partridge MS., Yale University Library. 58-page extract. It was made by William Partridge (H. C. 1689), who dated it: "11:9:[1687] Incepimus: Iterum Incepimus 18:12:1688 . . . Compendium hoc Physicum W. P. fuit finitum 13.2.1688."

1697

Greenleaf MS., Massachusetts Historical Society. 39 pages of synopses, 1-page index, and 96 pages of text and diagrams. This is the text used as the basis for this printed edition. It was made by Daniel Greenleaf (H. C. 1699) and is dated by this inscription: "Transcriptum et Finitum. Octob: 3. Anno. 1697. Per me D: G:"

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[1] "Harvard Text-Books and Reference Books of the Seventeenth Century," our *Publications*, XXVIII. 361–438.

[2] In collecting this information I have been aided by the courtesy of the officials of all the libraries mentioned, together with those of the Henry E. Huntington Library. I particularly wish to acknowledge the kindnesses of Mr. Stewart Mitchell of the Massachusetts Historical Society, Mr. Robert W. G. Vail of the American Antiquarian Society, and Mr. Gerald G. Wilder, Librarian of Bowdoin College. Photostats of the Bodleian MS. have been made available through the co-operation of Bodley's Librarian and the Harvard College Library; photostats of the Greenleaf, Eells, and Webb MSS. have been purchased for the General Library of the University of Michigan through a grant from the faculty research fund.

[3] The MS. carries the inscription "Ex Libris B Beale" and the date 1683 in handwriting somewhat like that of the transcription. For the Beales, see Horace Walpole, *Anecdotes of Painting in England* (1849 ed.), II. 537–545. There is little certainty, however, about this identification.

1697

Eells MS., Yale University Library. 173 pages (pages 135–138 lacking), with diagrams, and with synopses at the ends of chapters. It was made by Nathanael Eells (H. C. 1699), who dated it: "Ended October 28th In The year 1697."

1700?

American Antiquarian Society MS. 113 pages, incomplete (last half of Chapter 30 and all of Chapter 31 lacking), with some diagrams, blank spaces left for others, and a few synopses at the ends of earlier chapters. Its transcriber is unknown.

1701

Curwin MS., Massachusetts Historical Society. 52-page condensation. It was made by George Curwin (H. C. 1701) and carries the date "2do Martii 1700[/1]."

1707

Webb MS., Massachusetts Historical Society. 110 pages, with diagrams, and with a few synopses at the ends of chapters. It was made by John Webb (H. C. 1708), who states: "Transcriptum per me Johannem Webb, Tricessimo Die Julii Anno Christi Millesimo Septingentissimo Septimo." Webb's title-page, printed below, carries the date 1687, indicating that he worked from a manuscript copy made in that year and now lost.

1708

Ayer MS., Harvard University Archives. 172 pages, with some diagrams. It was made by Obadiah Ayer (H. C. 1710): "Transcriptum per me Obadiah Ayer Anno 1708."

1710?

Blake MS., Boston Public Library. 161 pages, with diagrams. It is said to be in the handwriting of James Blake (H. C. 1769), but it was perhaps made by Samuel Blake (H. C. 1711), in which case it may date from 1709 or 1710. The library catalogue card gives the date 1713; the dates 1721 and 1768 are on the flyleaf.

1713?

Brown MS., Massachusetts Historical Society. 95 pages, followed by a 1-page index; much abbreviated. It was made by John Brown (H. C. 1714), as appears from his autograph at the end. There is no date anywhere in the manuscript.

1160368

1714

Ward MS., Harvard University Archives. 113 pages, with a few diagrams. It was made by Robert Ward (H. C. 1719), who dated it: "Finitum . . . Calendis Octob: Anno Salutis Milesimo septigentesimo decimo quarto."

1715

Rogers MS., American Antiquarian Society. 172 pages, with diagrams, to which are appended 3 pages of "Rules to be observed in making an almanack," 6 pages extracted from John Wallis's article on tides in No. 16 of the *Philosophical Transactions*, 6 pages of "astronomical definitions," and 2 pages of mathematical problems. It was made by Nathaniel Rogers (H. C. 1717): "Began April the 18th 1715." "Finished August 29 1715 Per Nathaniel Rogers."

1721

Gridley MS., Massachusetts Historical Society. 198 pages, with blank spaces for diagrams. It was made by Jeremy Gridley (H. C. 1725). The title page has the date "Anno Domini Millesimo Septingentesimo Decimo Nono." At the end of his transcript Gridley has written: "Scriptum per me Jeremiam Gridley Anno D 1721 Laus Deo." The autograph of Mather Byles (1707–1788) appears on the title page.

The text which is here followed is that made by Daniel Greenleaf, corrected by collation with the Eells MS., the Webb MS., and, on occasional passages, with the two manuscripts at the Antiquarian Society. The Bodleian MS. has been used in a few instances. Brackets indicate either omissions by Greenleaf or the correction of scribal errors which obscure the sense. In either case the principle has been to preserve Greenleaf's reading except for obvious and bothersome mistakes where both Eells and Webb agree upon a variant. The spelling is Greenleaf's, as are the capitals and punctuation in all but a very few places where slight changes have been made for the sake of clarity. His paragraphing has not been regularly followed. Superior letters have been brought down to the line and the words spelled out. The diagrams are those made by Greenleaf.

The notions in Morton's *Compendium* flow to it from the past through many devious channels. In some cases Morton has culled more or less brand-new ideas from such contemporary sources as the Royal Society's *Philosophical Transactions*. More frequently his concepts must be referred back to the science and philosophy (never sharply distinct) of the Middle Ages, or even of remote antiquity. Usually, to be sure, they have been modified by some of the hot debates of the seventeenth century, a period of great intellectual conflict, but in a very real sense the *Compendium* is a microcosm of men's speculation about the external world from the time of Empedocles down to the eve of Newton's *Principia*—a span of well over two thousand years.

It is not surprising, therefore, that both the ultimate and the intermediate origins of Morton's information and theory are often uncertain, and that any study of provenience is bound to be fragmentary and uneven. I wish to suggest, however, in addition to Mr. Morison's comments, three general points of inquiry which have proved fruitful in reaching some understanding of the intellectual climate of Morton's book. Brief consideration of the more specific sources is offered in the footnotes.

It soon becomes evident that the *Compendium* is dominated by Aristotelian science. By virtue of centuries of pre-eminence in university studies, Aristotle clearly shapes the larger scheme of Morton's book, which follows roughly the traditional order in which the Schoolmen arranged the Aristotelian corpus.[1] Morton's second and third chapters simplify, systematize, modify, and yet are ultimately dependent upon the *Organon* and the *Physica*, the books of Aristotle which treat of logic and of the general part of physics, and which long formed the introduction to Aristotelian studies. Chapter IV takes on new meaning when it is thought of as a distant echo of the *De Caelo*. Chapters VI–XI reflect the *De Generatione et Corruptione*; Chapters XII–XVI are in large part similar to the *Meteorologica*, whose authenticity, now a matter of scholarly dispute, was not questioned in the Schools. For the remainder of Morton's book Aristotle's biological treatises are exceedingly useful, although not so closely related, those in point including the *De Anima*, whence come many of the definitions and divisions from Chapters XIX–XXX, the *Parva Naturalia*, and some of the treatises connected with the *Historia Animalium*. Even the *Metaphysica* has occasional paragraphs that have tangential relationship to terminology and distinctions employed by Morton. There can be no doubt that Morton was thoroughly grounded in his Aristotle as studied and interpreted by the Schoolmen. What commentaries he knew best remains one of the problems to be solved by some specially qualified scholar.

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[1] William D. Ross, *Aristotle*; William D. Ross, Editor, *The Works of Aristotle*, translated into English. The Scholastic use of Aristotle's scientific works is to be observed in numerous commentaries. St. Thomas Aquinas, for example, wrote commentaries on every book here mentioned except the *Historia Animalium*.

Morton's *Compendium* is also closely related to the sixteenth- and seventeenth-century revolt against Aristotle, as exemplified particularly by René Descartes. For reasons which will appear, Morton's ideas are not Cartesian in the degree to which they are Aristotelian, yet his book supports the belief of recent scholarship that Descartes was for a time more important in English thought than the much-honored Francis Bacon.[1] There is some reason to believe that Morton knew at first hand the *Principia Philosophiae*, perhaps even the *De Homine* and *Les Passions de l'Âme*;[2] there is better reason to think that he was familiar with some famous Cartesian text-books. Mr. Morison has shown that there were others who, like Morton, tried to reconcile the new knowledge with the old. His description of Adrian Heereboord's *Parallelismus Aristoteliscae et Cartesianae* (1643) and

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[1] Sterling P. Lamprecht, "The Role of Descartes in Seventeenth-Century England," *Studies in the History of Ideas* (edited by the Department of Philosophy of Columbia University), III. 180–240.

[2] Cf. (except for the *De Homine*) Elizabeth S. Haldane and George R. T. Ross, Editors, *The Philosophical Works of Descartes* (translated into English). Part IV of the *Principia Philosophiae*, most important for comparison with Morton, is barely outlined; for it and for the *De Homine* it is necessary to consult the originals.

Meletemata Philosophica (1654) indicates a type of transitional text-book long popular at Harvard.[1] Closer in spirit to Morton were later disciples of Descartes: Jean Baptiste du Hamel, Jacques Rohault, and Antoine Legrand. Du Hamel was the author of *Philosophia Vetus et Nova ad Usum Scholae Accomodata* (4 vols., Paris, 1678); Rohault, of a *Traité de Physique* (Paris, 1671) which was many times revised, translated into Latin and English, and served as a popular text-book well into the eighteenth century. Legrand lived for many years in England, and wrote a number of books organizing the Cartesian ideas into Aristotelian order. Of these the most famous was *Institutio Philosophiae, Secundum Principia R. Descartes, Novo Methodo Adornata et Explicata ad Usum Iuventutis Academicae* (London, 1672). Later translated by Richard Blome as *An Entire Body of Philosophy According to the Principles of Renate Des Cartes* (London, 1694), this book was probably known to Morton. It follows the Aristotelian order very much as does the *Compendium*; it includes a number of diagrams strikingly like Morton's; it makes many of the Scholastic divisions in language almost exactly the same as Morton's; and it even uses (though infrequently) the device of mnemonic verses which is such an integral part of Morton's method. Many of Legrand's verses come from Lucretius or Ovid, but he is sometimes original, as in this brief summary of the universe:

Mind, Measure, Rest, and Motion,
With Figure, and Position,
To Matter join'd, the Causes be
Of all what here below we see.[2]

Morton and Legrand (or perhaps Legrand's translator) clearly belong to the same school of poetry. Indeed, it is hard to escape the conviction that Morton owed his method, and a good deal of his matter, either to Legrand or to some contemporary extremely like him.

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[1] Morison, *Harvard College in the Seventeenth Century*, pp. 233–234. Other such text-books, to which Morton's is vastly superior, include Daniel Widdowes, *Natural Philosophy* (2d ed., 1631), John Johnstone, *An History of the Wonderful Things of Nature; Set Forth in Ten Severall Classes* (1657), and *Thirteen Books of Natural Philosophy by D. Sennert*, translated by Nicholas Culpeper and others (1661).

[2] Richard Blome, *Entire Body of Philosophy*, p. 106.

The *Compendium* reflects far more than superficially the stage of English thought represented by Robert Boyle and the early years of the Royal Society. Boyle is not only cited more frequently than any other contemporary writer, but portions of his work also provide much of the matter for several of the chapters.[1] Morton's extensive acquaintance with Boyle's writings accounts for his tendency to shy away from Cartesianism, even though he does not go the length of accepting atomism or corpuscularianism, which Boyle, with certain theological reservations, embraced, in company with Pierre Gassendi and others.[2] Moreover, other members of the Royal Society than Boyle provide much grist for Morton's mill, John Wallis, Robert Hooke, and Henry Power being particularly in point, as will appear from the notes. From the present-day point of view, these connections are most creditable to Morton, since they constitute his strongest claim to "modernity." Because of them, he ordinarily rejects Descartes, even where Legrand had most enthusiastically accepted him. And there are enough such connections to justify placing Morton, despite all his faults of omission and over-simplification, at approximately the Boylean stage in the development of modern thought.

It is helpful, in short, to think of Morton's work as formed by three modes of thought, each of which has been of inestimable value to the intellectual life of the western world. It owes much to the Aristotelians, a good deal to the Cartesians, and most, perhaps, to the much-honored leaders of the Royal Society, who, outlawing theology and politics in their discussions, set out to realize Bacon's dream of the advancement of learning and the conquest of nature.

Boyle, Morton's chief scientific master, had said long before the date of the composition of the *Compendium* that men who sought to write complete systems of natural philosophy had to face the alternative "either idly to repeat what has already [been] . . . written by others on the same subjects; or else to say any thing on them rather than nothing, lest they should appear not to have said something to every part of the theme, which they had taken upon themselves to write of." By the very nature of things, Morton's was an impossible task. But he undertook it, we may be sure, in the spirit of Boyle, who had gone on to say that "such a work may be useful, partly, for the instructing of youth in schools and academies; and partly, that men may have, from time to time, an inventory of what hath been already discovered; whereby the needless labour of seeking after known things may be prevented, and the progress of mankind, as to knowledge, might the better appear."[1] In the pursuit of at least the first part of such an intention, Charles Morton brought to the American colonies some measure of the scientific spirit and some tincture of the scientific mind.

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[1] Cf., below, Chapters 2, 6–8, 12, 15, 17–20, 23.

[2] See Morison, *Founding of Harvard College*, pp. 250–251. There are two eighteenth-century editions of Boyle's works, one in five volumes in 1744, the other in six volumes in 1772. An indispensable guide is John F. Fulton, "A Bibliography of The Honourable Robert Boyle," *Oxford Bibliographical Society Proceedings and Papers*, III. 1–172, 339–365.

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[1] *Certain Physiological Essays* (London, 1661); in *Works* (1772 ed.), I. 300.

Compendium Physicae

EX AUTHORIBUS
EXTRACTUM
A DOM: CAROLO MORTONO
IN USUM
EORUM ENITENTIUM
PHYLOSOPHIAE OCCULTA
ELUCIDARE.

Anno Dom:
1687

A System of Physicks

The Preface

THE Usuall Proem of Physicks Shew it to be a proper science in that it hath all the requisites which to Science do belong; viz: the End Contemplation, and the Object a real, and necessary being.

1. The End Contemplation; the End indeed of the Scient, or that which puts a man upon the Study of nature, both may, and should be, both practice, and operation, and that in many wayes, as Medicine, Husbandry, and all Handycrafts, and trades which can never be well handled without some understanding of the nature of those things which we have in hand; Yet the End and last design of the science it self is to enable a man to contemplate and meditate upon the nature of bodyes, the same may be said of all other sciences.

The scient meditates for opperation
The science hath its end in contemplation

2. The Object or Subject handled is Natural body a real, a necessary being; Necessary in the Genus, body, and the species thereof Though allwayes very mutable in its Individuals. 'Tis Necessary that body in General or any of its Species, i.e. whatsoever is a body Should have matter, Form, time, Place, etc: though in this or that particular body the matter may be altered, the form distroyed, the time ended, or the place Changed.

Body in General is necessary,
but in the Individuals doth vary

Now because of the necessity which is scientifical there are many things in nature most certain and demonstrable; [and yet it must be acknowledged, that the Doctrine of] Bodyes admitts of more disputes than any other part of Phylosophy; So that the Greatest part of it is made up of oppinions, and conjectures how that comes to pass which appears to be; this they call the Solving of the P[h]ainomina of nature.

You may remember in Logick[1] the rule of settling probable oppinions is by sence, observation, Experience, and induxion: Now because some things fall out in one place, or age, more observable than in another; and because also men in several places, and times are born, of more than ordinary Reach, Sagacity, Opportunities, Encourragements, etc: and lastly because there is a mutuall [Subserviency] of arts, and Sciences (like Stones in an Arch which support each other) and Some of these have been at Several Seasons, and by degrees improved (as for instance, Printing, Optick Glasses, Chymistry, Anotomy, Botanics, etc:) hence it is that latter observation do contradict the former Hypotheses (or Suppositions) and therefore these new discoveries do beget New Suppositions; which after observations will be again regulating; so that in this matter we cannot say Certainly what is the very truth, but what seams most probable according to the discoveryes already made. And hence Grows a distinction, of the Old, and new Phylosophy, and there will be newer still (in all liklyhood in some particulars) even unto the end of the world.

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[1] The Massachusetts Historical Society owns two transcriptions of Morton's "Treatise of Logick," another of his manuscript text-books which was used for a time at Harvard. One was made by Timothy Lindall (H. C. 1695); the other, by Daniel Greenleaf, as extracted by Jabez Fitch, is in the same notebook as his copy of the *Compendium*. The nature of Morton's logic appears from later references; see especially below, p. 10, note 2.

Where New apperance is before the Eyes,
New Suppositions thereupon arise

And Yet (notwithstanding this Uncertainty) it is not impertinent for men to be inquisitive into the mystery of *nature natured* (the Creation) which is the work of *nature naturing* (the creator) because it makes for the Glory of God; and our own Good: Yea it is his command that we should meditate upon all his works both of Creation and Providence; Hence Davids practice (Psalm 143. 5.) I [2] *Meditate on all thy works. I Muse on the Works of thy hands. This is the travel that God has Given unto the Sons of men to be exercised in it* (Ecclesiastes. 3. 10.) Yea tho it be perfectly unconquerable by them. *He hath mad every thing beautifull in its time; Also he hath set the world in their heart, So that no man can find out the work, that God maketh from the beginning to the End* (Verse 11.) So also (Job. 11. 7.) *Yet hath he set it in their heart,* he hath given them an Instinct of Enquiery and Pleasure Concomitant to Encourrage them; the works of the Lord are Great Sought out of all them that have pleasure therein (Psalm 111. 2.) and hence it is as (Proverbs. 18. 1.) *through desire a man having seperated himself, seeketh and intermedleth with all wisdome;* A fool hath no delight in understanding, etc: So that you See 'tis natural Theology that men should be industrious in Natural Phylosophy.

Though man can't fully know what God hath done
Yet tis his duty still to think thereon.

Besides the Will of God, the need, and convenience of man may stir us up thereto; for whatsoever is our Rayment, Meat, or Medicine hath its Ground in Naturall phylosophy, or knowledge So much as we can get thereof. 'Twould be convenient to have Good knowledge therein for husbandry, and Household affairs; but the Physitian had need be very expert, a Man of Great industry, and Sharp observation, and of a Judicious composure of mind to make Solid inferences from well observed Experiments; Men of Esculapian Genius, and not the Dulheads of the universities who are of too loose Inclinations to be listed among the Clergy.

All men had need of Physick[s], but Physitians
Should be herein not fidlers but Musitians.

This I thought good to præmise that you should not be dishartned when you meat with diversities of oppinions in the folloing discourse: and because the former Phylosophers had their Method more Systematical, than the latter; I have therefore Chosen their method, and noted the Others Matter by the Way in those places where I observe a discrepance.

Chapter 1

Of Physicks or Naturall Phylosophy In Generall

[Of Physicks in Generall, note its Definition and Division.[1]]

1. Definition. Physicks is Science of Natural body; *as Natural.* In this observe the Genus and Difference.

1. Genus, Science, haveing all its Requisites (as is Shewed in the Preface).

2. Difference (From Other Sciences) taken from the Object [Body, as naturall, the formality or difference of this object lyes in the words] (as natural). Materially natural body may be the Object of Several Arts, and Sciences; as, of Mathematicks—(as Measurable) Opticks (as Visible) Medacine (as healable) etc: But formally as Natural is the proper object of physicks only. By Natural is meant haveing Mater and form conjoyned, and diverse affections, Accidents, or Properties consiquent upon that conjunction, (as is after more fully Shew'n.)

Medicine, opticks, Mathematicks all.
Of body treat; Physicks as natural.

2. Division of Physicks into two Parts
- General, and
- Special.

1. The General Part treats of Natural body in General, with its Generall principles and affections.

2. The Special part is of the Several Species thereof distinctly considered either distributively, or Collectively.

1. Distributively, and Seperate, and So natural body is [3] either
- Simples as Elements, of which other bodyes are made.
- Mixt
  - Imperfectly; as, Meteors.
  - Perfectly
    - Inanimate; as,
      - Stones,
      - Metals,
      - Minerals.
    - Animate
      - Insensible; as, Plant.
      - Sensible, as Animal
        - Irrational Brute.
        - Rational man.

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[1] This and the following chapter are based ultimately upon Aristotle's *Physica.* The divisions, however, are typically Scholastic, and one can see the same method and terminology in other text-books. Compare, for example, Antoine Legrand's *Institutio Philosophiae* (London, 1672), Pt. IV, ch. i. In Richard Blome's translation is the information that: "*Natural Philosophy* . . . or *Physiology,* is *the Science of Natural Bodies, and their Various Affections.* . . . And those are called *Natural Things,* or *Bodies,* which are endued

2. Collectively, (or joyned into one Mass,) and So Natural Bodyes considered are called World, (or Universe.)

Bodyes into their Several Kinds disperse,
Or [els] collect, and call it Universe.

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with *Nature*, or that are compounded of *Matter* and *Form*. . . . *Natural Things* are considered two manner of ways in Physiology, either *Generally* or *Specially*." *Entire Body of Philosophy*, p. 93.

Chapter 2

Of The General Part of Physicks

IN this are considered 3 things the Object, Its Principles and affections

1. The Object, (or Subject handled) (Natural body in General), as it is precinded from all its Species by precisive abstraction, and considered not as any particular body but only in General as it is contradistinct to Spirit in the Division of Substance; body hath matter Spirit hath none.

Body in General Precinds from all,
The Species that under it do fall.

2. The Principles on which natural body dos depend as a thing principled ([i.e.] taking begining, for, from, by, out of them) are of 2 sorts External, and Internal.

1. External are those by, and for which (not out of which) natural body is made, and these are the 2 External causes Efficient, and End.

1. Efficient, whose deffinition in General is treated of in Metaphysicks but as applyed to natural things 'tis defin'd by Aristotle[1] that principle by which mutation is made [at] first really.

2. The End, the principle for which (or for whose Sake) a thing is, this is first intentionally, as the Other is really; for the End first moves the Efficient to act.

Externall principles are what doth make,
The Efficient; the End is for whose sake

2. Internall principles defin'd by Aristotle, those [that] are not made up one of another, nor of any [other] thing as Physical components, but out of them are all things, either as Components or terms. Components, Matter, and Form; Term, Privation.

1. Privation (Physical) is an absence of Some form [to be introduced. The words (to be introduced) make it differ from privation (Logicall,) which is the absence of any form] whereof the Nature is capable, without respect to its future Introduction. Thus the blindness of a Dog before the 9th day is a Physical Privation; because Sight will Naturally come in its time; but if the Dog be made afterwards fully blind, the same Numerical sight cannot be recall'd, or become future; and therefore it is a (Logical)

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[1] The specific references to Aristotle in this chapter are to distinctions made in the *Categoriae*, the *Physica*, and *De Generatione et Corruptione*. Morton, following Scholastic precedent, is more systematic than Aristotle will be found to be.

Privation. So absence of life in an Embrio (or yet imperfect Animal) is a Privation (Physical;) but In a Carcase 'tis (Logical). Hence that common saying from Privation (Physical) to Habit, is progresse; from privation (Logical) to Habit, is not regresse. Therfor Lazarus, and Bartimeus[1] had not the Same numerical life, and Sight restored to them, but a new created by the power of Christ, and bestowed upon them.

(Physical) Privation notes futurity;
but (Logical) doth still the same deny.

This Physicall privation is the principle of Generation only, and not of the thing Generated. Of the Generation, because it [4] is in the deffinition thereof; for Generation is a change from Privation (or not being) to being; not of the thing Generated, but, by Accident; for it is of too mean a nature as a Privative to produce a Positive being, and therefore Some allow it to be only a condition (without which a thing cannot be) and not a Principle at all. Such a condition indeed it is; for a thing cannot be made, but out of, or from (as a term) that which it is, or has, not: So the Prolifique seed must first be Void of the Soul; before that by the Union of the Soul thereto it be Generated or become an animal.

Not of the thing Generated Privation,
Is Principle; but of the Generation.

2. Form is a Substantial (or rather Essential) principle of natural body which by active Union with the Matter doth constitute it in Some Species of bodyes. So the Rational Soul (the form of man) united actively with the Humane body (the matter of Man) doth constitute him in the Species of man distinct from other animals. Therefore the Soul seperated is not man; nor the body after Death (for it is then but a Carcase) but only when they are in Essential Union, as before death and after the resurrection.

N.B. The word (Form) is Used very Equivocally. In Logick it is taken for any positive accident, that inheres in a Subject, and So it is opposed to Logical privation (the Absence of any positive form; i.e. Accident) So also it is Used in the antiprædicamental denominations,[2] and Concrete words, where we find a form, (i.e. an Accident) denominating. And thus analogically it is applyed to things of art, Speach, Moral actions, etc: [Whence] the distinction of material and formal (as you see in the

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[1] See John, xi, and Mark, x: 46–52.

[2] Morton assumes that his readers, with the background of his text-book on logic, are familiar with the basis of all Scholastic dialectic—Aristotle's ten predicaments: substance, quantity, quality, relation, place, time, position, state, action, and affection. These are named in the *Categoriae*, ch. iv, and again in the *Topica*, Bk. I, ch. ix.

Use of Logick) is said properly to belong to body but by Analogie (proportion, or Similitude) it is applyed to concrete Accidents, especially in artificials, in objects, in terms of the 1st and 2d notions. But here in Physicks it is taken only for the Cheif Essential part that gives Specifically being to a natural body, and therefore also it is called Substantial form to distinguish it from all accidents, which are said to be consequentia[ll] and Secondary to the form; and many of them do arise from it; as others do arise, and follow from the matter. 'Tis not indeed a Substance nor directly in the first predicament; because it is an incomplete being in that it is but a part; yet 'tis Said to be Substantial because it is an Essential part of a true Substance, namely, body. But latter men do think the Essential form of most things to be made up of an aggregation of accidents; and therefore do not allow the term (Substantial) to any form but the Soul of Man. See Mr. Boyles treatise of essential forms.[1] This form is a principle of constitution only to the natural body, whereof it is an internal constituent part; not of the Generation, whereof it is a Consequent.

Essentiall form is but a Constituent,
Of body; Generations consequent

'Tis 2 fold Material, and Immaterial.

1. Material is that which is materially educed from the power of matter, that is not made out of matter because it is a principle; but depending thereon as to being, 1st Production, and after, conservation. So the forms of brutes, and Inanimates are said to depend on matter; for if they are Seperated from their bodyes (or matter) they Cease to exist, or be; whereas the form of man (his soul being a Spirit) doth exist in a state of Seperation. This is pointed at Genesis 2. 7. Man became a living Soul, [5] Whilst other Souls are perishing and dyeing. The forms of brutes they say when seperated, are not wholly annihillated, but reduced into the Power of the matter.[2] This Eduction, and Reduction, is explained by a Simmile of Soft wax which hath actually but one figure (say round) but it hath in it potentially all figures (as Square, Long, etc:) Now if you press the round ball into a Square you do educe the Square figure out of the power (or Capacity) of the wax; but at the same time and by the same act you do

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[1] Robert Boyle, in *The Origine of Formes and Qualities* (Oxford, 1666), summarizes much of the anti-Aristotelian thinking on the concepts of form, matter, motion, etc. This book Morton knew well. Compare, however, Descartes, *Principia Philosophiae*, Pt. II.

[2] Morton's discussion of matter appears to depend in part upon Boyle's *Some Physico-Theological Considerations about the Possibility of the Resurrection* (London, 1675). The simile of the soft wax which may be molded into any desired form is developed there in terms very like those used by Morton.

reduce the round figure into the power of the matter; from whence you educe it again at your pleasure by rolling the Square into a ball.

Material forms on matter do depend,
And into matters power, reduc'd have End

2. Immaterial form is that which doth not at all depend on matter but only as to the act of informing; for as to the act of being it can and dos Subsist without it, and seperate from it; because it is a Spirit created indeed with Some relation to matter, whereby it differs from an Angel, but as to being without dependance thereon. This is the Noble Soul of man, of which Somewhat before, and more hereafter in its proper place.

[3.] Matter is a Substantial principle of natural bodyes constituting it by passive Union with the form; or (as Some) it is a principle out of which natural bodyes are made and into which they are at last resolved, Its self still remaining the same under all Changes: So the Same particle of matter may pass under diverse forms in diverss bodyes, and yet never be distroyed or lost; as in a man, Earth, Grass, beasts, and man again (as to [Alimentary] parts) and So on through never so many more mutations as you can Imagine.

N.B. The Words (as to [Alimentary] parts) are added to Signify that seminal parts of a man do not pass from one man to another by being added to another Substance in nutrition; but are alwayes kept distinct that so the Doctrine of the Resurrection may be better conceivable by humane reason, to be, not contrary to, though above nature, but the [Alimentary] parts (which are alwayes Changing) may become nourishment to another without contradiction of the raysing again of the same numerical body; for if all these Should be accounted as necessary parts to the same body, to which they once ware affixt, then every Individual man that dies at any Considerable Age, must be raysed as bigg as a Mountain which would be too harsh for us to conceive.

Matter is Passive in the bodyes frame,
And under every thing remains the same.

This Matter is a principle both of Generation, and of constitution; Of Generation because [it] is the Subject wherein it is performed (Naturall Generation being alwayes out of præsupposed, and prædisposed matter.) And herein it differs from creation which is either not out of matter or out of matter Inhabile, and Indisposed for such a form: As, To produce a Man out of the earth; Woman out of a Ribb; bread out of Stones, etc: Such things do allwayes require a Supernatural power to do them. 'Tis also the Principle of constitution because with form it concurs to constitute the Natural body

Matters [Substance], where Generation's done,
Part of the bodyes constitution.

Matter is considered in a 2 fold state and So distinguished into $\begin{cases}\text{first}\\\text{second}\end{cases}$

First Matter is conceived void of all forms, and capable of all; Not that there is, or ever was, or ever will be [any] Such matter existing in the world: For that confused lump which (Genisis. 1. 2.) is said to be without form Called [by] the Poets Chaos had Some form sutable to that confusion; but it was void of the form, Comliness, and Order, which by degrees appeared afterwards in the several Species made thereof. Yet notwithstanding we may abstract matter from all forms and conceive of it in its own distinct nature [6] (like Wax that hath no figure impressed thereon) and So abstractly conceived; It hath 2 Attributes, power, and Indetermin'd Quantity.

1. Power this is 2 fold Universal, and particular.

1. Universal, whereby it is able to receive all forms of bodyes Successively into it (like the said Wax capable of any figure you please to impress) and in this power 'tis said the Essence of matter dos consist.

2. Particular, whereby it is aptly disposed, through the Efficiency of some External Agent to receive a particular form; as, When the Embrio is Organized fitt to receive a Soul, (i.e.) hath members fitted to the souls opperation and then it is disposed, or prepared to receive the Soul as its proper form.

2. Quantity undetermined, i.e. Quantity in its self considered; Not that it hath no term at all; (for there is no Quantity but is finite and so must have its terms) But as it is a dependent on matter without Physical Determination by any particular form. Now as Matter is apt to receive this or that form; So this (its Undetermined Quantity) is apt from the form to receive this or that Physical determination; for every Physical body requires certain terms of its Greatness [and] littleness: they have a Greatest as Such [and] a least as such: therefore Gyants, and Dwarfs are monsters in nature, and have not the proper Physical body of men.

Second matter is the same really with the first only as it is informed with a particular form. Even as the Wax is the same both before, and after some signiture or Character is impressed upon it therefore it is commonly said 1st matter dos exist in 2d.

N.B. The Antients Doctrine is that all Generations, and Corruptions are made in first matter: for tho indeed the Matter as to its present form, which it hath, (no matter being without one) is truly 2d matter, Yet (say they) as to the form it is capable of and prepared for its 1st matter; So that the [true] difference of first, and Second matter liyes in the capacity, or possession of forms.

The first, and Second matter really
[Are one, distinct] by a formality.

These 2 Principles last mentioned (Mater and form) may be considered not only as constituents (of which is Spoken) but also as Efficients; namly [as] conjoyn'd, they produce all the affections (Attributes, or Properties) of body; and So taken togather, they are called by one name (Nature) which is defin'd the primary and Direct principle of motion, and rest successively in the body wherein it is.

N.B. By Motion, and Rest is not meant those things actually, but potentially (which we may call mobility, and Restibleness) For Some things never actually Move; (as, the Center of the Universe) and Some never Rest (as the Heavenly bodyes) and yet both have the Power of motion and rest, (at least passively) Supposing there be a Sufficient Agent to produce them.

N.B. By Primary, and Direct, is meant properly of its self, and not by accident to distinguish nature from art, or Accident from art as in a Clock, which moves by Art round to shew the time of the Day; Whereas by nature without art it moves downward, (and obstacles being removed) fals to the Ground. So also by accident as a Man sees by his visive power (a Quality, an Accident) but not primarily, for that is from the Nature of an Animal to which that power belongs; nature is 2-fold Universal, and particular.

1. Universal is a Principle of Motion and rest; whereby bodyes are carryed contrary to their particular natures, to preserve the Universe, (like Good subjects in a Common wealth who will foregoe their private Interest for the publique benifitt;) So heavy bodyes assend (being Sucked up) to avoid a Vacuity which Universal nature doth abhor.[1]

2. Particular is a principle of motion and rest in every particular body for its own conservation; So heavyes descend, etc:

Nature particular itself resigns
To correspond with Universe designs.

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[1] This, as Mr. Morison has shown, was a principle of ancient natural philosophy which Morton was especially loath to give up. See *Harvard College in the Seventeenth Century,* p. 241.

Chapter 3

Of The Affections of Natural body, in Generall

THESE are 4. Quantity, Place, time, and Motion.[1] (Some add a 5th. Viz: Quality.)

1. Quantity determin'd, which as to its Essence or being (extention) flows from the matter; as to its determination from the form, and from this it is that bodyes are extend-[7]ed, Finite, Divisible.

1. Extended, as to have parts out of parts which cannot be togather, in the same part of the whole space; and hence every body, and all parts of body do so possess space that no other body or part can come thereinto unless that be removed which was therein; See the Chapter of Quantity in Logick.

2. Finite because of the determination; therefore we must conceive bounds to this Universe tho we know not where, (or how far off) they are; Hence one defines body Matter, and figure considered togather (Dr. Petty of Duplicate proportion)[2] Now Figure is the termination of Quantity, or at least Supposes the terminations and there is no body but hath its figure.

3. Divisible Infinitely (as is explained in the prædicament of Quantity Namely by our thoughts, though not by our hands) but indeed this is scarse alowable to Physical body, though it may be to mathematical; there is a least Physical (which they call attome, i.e. not able to be cut) but then some of the Atomists, or Corpuscularian Phylosophers[3] say Atomes are Indivisible from their Solidity not from their littleness.

Bodyes determin'd Quantity whereon,
Extent, Finitenes, and Division.

2. Locality or place which is commonly distinguished into External, and Internal.

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[1] Morton's distinctions here should be compared with those in the *Physica*. His six species of motion are exactly correspondent to those in the *Categoriae*, ch. xiv.

[2] William Petty, in his *Discourse Concerning the Use of Duplicate Proportion* (London, 1674), attempted to re-define such concepts as place, time, and motion. See a convenient review of the work in the *Philosophical Transactions*, No. 108 (November 23, 1674). Morton seems to be indebted to Petty not only for materials in this chapter, but also for portions of Chapters 2 and 6.

[3] The chief of the "Corpuscularian Phylosophers" was Pierre Gassendi, but Descartes and Boyle were sometimes, and with reason, counted among the corpuscularians or atomists. See under *corpuscle* and related words in the *New English Dictionary*, and, for a brief discussion of the importance of the atomist hypothesis, Morison, *Harvard College in the Seventeenth Century*, p. 250.

1. Internal the bodyes presence in its Space, this is scarce distinguishable, even by our thoughts from its extention or corporeity, and therefore cannot be its accident or affection; This I Suppose Dr Petty means when he [defines] place the Image or Phancy of matter; or matter considered.

2. External with which we have here now to do is defin'd (by Aristotle) the hollow Surface of the containing body (conceived as immovable) of which in the Prædicament of Quantity, and Whereness; (by Cartes)[1] the Vicinity, (or neighbourhood) of one body to another. And this indeed seams to be the better of the two, and will better explain the nature of [Locall motion].

This is either Locality or Locability.

1. Locality (or actual place) So it belongs to every body, except the Utmost heaven, which is only in the Abysse or Imaginary Space that hath no hollow Surface or Neighbouring body.

2. Locability (or potential place) and so it also agrees to the Utmost body; for that also hath an aptitude to be in a Circumscriptive place, or Visinage of bodyes, if there had been any such larger or neighbour bodyes created for it.

Bodyes have place; actual Locality,
At least potential Locability.

3. Time in like manner is distinguished into Internal, and External.

1. Internal time is no more than a things permanence, and duration in its existence this is not here meant

2. External defin'd by the Antients the Number or measure of motion according to before and after which they explain thus. The measure of such a motion which hath some parts going before, and others following, whereby it is apt to measure the duration of other things. Such a motion is in the wheals of a Clock; the sand of an hour-Glass; or ones going to a place and back again: and this [applied to] the duration of other things Sheweth them to have lasted one or more hours. But because all those Sublunaries are unsteady, and Variable, and So deceive us (for Somtimes the Clock Strikes Earlier, Somtimes later than it Should) therefore here is principly to be understood the motion of the heavenly bodyes (which is more regular and constant) as that of the Sun, whereby hours, Days, and Years are measured and that of the moon which measureth, and Denominateth months. Thus by the Motion of the Center of the Sun 15 Di-

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[1] Morton's references to Descartes suggest either direct knowledge of the *Principia Philosophiae* or acquaintance with such a text-book as Legrand's. Legrand covers the same ground in Pt. IV, chs. xi-xxv, with ch. xii, which discusses place, chs. xiv and xv, dealing with local motion, and ch. xxiv, which treats of time, being especially in point.

grees, or $\frac{15}{360}$ East to west of that whole circle wherein it is ([that day] Supposed to move) we measure and account the time of an hour; and by its motion from West to East round its Supposed anual Circle we measure or account the time of a year: then by applying the duration of the Sun in motion to the duration of any other body, or bodyly action we say it hath lasted (or had duration) an hour, a year, etc: Of which see more in the prædicaments of Quantity and Whenness. This Measure of the duration of bodyes is called external time because it's external [to the Bodyes measured by it, tho it be Internal] to the Sun or its motion. [8]

N.B. Dr. Petty among the Novel deffinitions cals time the Image of motion: but I think it is more intelligibly expressed by the measure of durations or (as Mr Boyle) duration measured[1]

Duration measured by heaven motion
Gives of External the perfect notion.

4. Motion (or rather Mobility) the passive power is a Change from one term to another; the 2 terms are from which, and to which; from which is that which is left in motion; to which is that which is acquired; and from this latter motion derives it's Unity; for if I move my hand to a place, and make 3 stops by the way, then have I so many terms, and therefore move that distance by 3 motions: whereas if I make no stop tis all but one motion having but one term (to which) at the End thereof.

Species of motion are commonly accounted 6. Whereof Instantaneous, 2. Successive 4.

1. Generation is a Motion from an Essential form not being to its being in the matter; as the Generation of a man.

2. Corruption is on the Contrary from being to not being: as the death of a man. These two are called Instantaneous, not that they are in the same instant; but because they are in 2 Immediatly succeeding Instants; For So a man may be alive in this Instant, and dead in the next.

N.B. 'Tis a common Saying the Generation of one thing is the corruption of another; and So on the contrary; as the Generation of Ashes is the Curruption of Wood. Tis true conseqentially, but not formally, for they are 2 distinct effect of the same a[c]t.

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[1] Boyle's definition of time as "duration measured" is thought by Mr. Morison to have come from either *The Excellency of Theology* (London, 1674) or *The Great Effects of Even Languid and Unheeded Motion* (London, 1685). The words also occur in *Some Considerations about the Reconcileableness of Reason and Religion* (London, 1675), by "T. E., a Layman," a tract to which Boyle's *Possibilities of the Resurrection* was appended. See Boyle, *Works* (1744 ed.), III. 525.

2 Motions Generation, and Corruption,
Of both is Instantaneous production

3. Augmentation is motion from less Quantity to Grater as the filling a Vessel.

4. Diminution is from Grater to less; as in Emptying a vessel.

5. Alteration is from one [Quality] to another; tis either Essential, or Gradual.

1. Essential from one Kind to another; as from hot to cold.

2. Gradual from one degree to another; of the same Quality; as, from Hot, to Hotter.

6. Location (or locomotion) is from one place to another this only is allowed by later phylosophers to be true motion; for Augmentation, and Diminution are included in the same, and the rest they call mutations not motions.

Generation, Corruption, Augmentation, Diminish, alteration
Are Changes, th'only motion is location.

'Tis divided in respect to the line and principle.

1. Line in, or by which it passeth; and So tis either Simple or mixt.

1. Simple, made in one Simple line, and So tis either right, or circular.

1. Right, to and from the Center.

1. From the Center to the Circumference, called assension, proper to light, or less heavy bodyes; they being thrust up to make way for the heavier; as, Wood, or Cork put to the bottom of water assends to the top thereof.

2. To the Center from the Circumference called descent proper to heavy bodyes, as a Stone put to the top of water discends to the bottom thereof. The cause thereof is much disputed whether from a magnetical virtue in the Globe of the Earth or from a Quality in the body discending called Gravity. but let Gravitation be from what cause soever; Certain it is that its necessary to hold all the parts that belong to a Globe togather; or else they would soon disperse themselves, and the concrete body vanish; So that if matter should never perrish, the distroying of but this one Inclination, and common bond, would Soon dissolve the Universe whose Atomes wandring in the [Abyss] would quickly lose themselves.

2. Circular, is made in a line whose parts are Equally [distant] from the Center of the motion so moves a Wheale, a Pendulum, (i.e. a bullet hung up by a line, when it is put a Swinging) So moves the planets about the earth, and the Earth (or [terraqueous] Globe) Probably about its own axis.

2. Mixt motion is done by a line, partly right and partly Circular. Such

is the motion of a Arrow Shot Straight, for a while, and then it turns down in a peice of a circle, towards the Earth.

Simple right up, [or] down, or Circular
Or mixt the lines of locomotion [are].

2. In respect of the principle from whence the motion doth arise, and So tis either natural Violent or Mixt.

1. Natural as when the principle of motion is within the body, as the discent of a Stone; that is from Som natural power, either Active whereby it contends or endeavours downwards (as the Antients will have it) or passive whereby tis capable to be attracted to the earth (as latter men would have it.) [9]

2. Violent when the principle is out of the body; as, when a Stone is thrown upwards.

3. Mixt, When addition is made, to the force of nature, as when a Stone is thrown downwards.

The Opposite to motion is Quiet, or rest, which in respect to motion [is either]

1. Ending before, and So tis privation, of motion.

2. beginning after it and then tis the perfection thereof this resolves a doubt whether rest be a positive or privative thing.

All Motion, Nature, force or both commands,
Opposite rest before, and [after] stands

As to the 5th Affection of natural body Quality (as Some would have it reckoned) tis various and consequent upon particular nature of the Several Species rather than one or from the General nature of body and therefore belong to the Special part of Physicks whither we shal refer it.

Chapter 4

Of The Special Part of Physicks [And first of The Heavens in Generall]

THE Special part of Physicks treats of the Species of bodyes, and the first distribution is into Simple, and mixt.[1] Simple body is that which is not composed of other bodyes, and those the Antients thought ware heaven, and Elements.

N.B. The Ground of the Antients to pronounce the heavenly bodyes simple, was because they could observe no Changes, Generations nor Corruptions in them. but by the late invention of Tellescopes (besides other Reformations in Astronomy) there is also another doctrine of heavenly bodyes, for (Say the latter Phylosophers) had Aristotles Eyes been placed in the moon, or any other of the Cœlestial Globes, he would have seen no more alterations in this our Earthly Globe with the naked Eyes, than he did from the Earth desern in the heavens. But our Eyes by the help of this new art being fortified above a 1000 fold can see there those things which he could not Generations, and Corruptions, and many other matters; We can see in the body of the Moon hills and Dales, Water, and Dry-land, we can see above the Moon Meteors and comets, and about the Sun Clouds and Steams, etc: Therfore certainly many of the Cœlestial [globes] are concreat bodyes, as our Earth is, and are no more simple than this. Upon this consideration rather let us divide natural bodyes, as the Scripture doth (Genesis. 1.) into heaven, and Earth, and then Earth into simple, and mixt.

1. Heaven or Cœlestial body is all the rest of the Universe, (the Aspectable (or Visible) world.) which is farther distant from us than our highest Air. As for the Invisible world, (the heaven of heavens, the throne of God,

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[1] The organization here suggests Aristotle's *De Caelo* and *De Mundo*, but the information is almost wholly from more modern sources. It is doubtful if Morton knew at first hand all the scientific writers whom he cites: Ptolemy, Pythagoras, Copernicus, Kepler, Gassendi, Tycho Brahe, and John Wilkins. Most of them are mentioned in Legrand, *Institutio Philosophiae*, Pt. v, chs. viii–xi, where there may also be seen three diagrams very similar to those in Morton. Such information and diagrams were common in other text-books and popular treatises of the period, although they were originally taken from such books as the *De Revolutionibus*. See, for a study of the provenience of these materials, Francis R. Johnson and Sanford V. Larkey, "Thomas Digges, the Copernican System, and the Idea of the Infinity of the Universe in 1576," *Huntington Library Bulletin*, No. 5, pp. 69–117. Morton diverges sharply from Legrand by omitting all mention of the Cartesian vortices.

the Seat of the blessed Angels, and Saints) we are not here to treat of; that 3d heaven (as the Apostle cals it) or Empireal (as the Phylosophers) is above Phylosophycal notions; but there is a first and Second which they make bold to meddle with. The 1st is Ærial, (whence birds are called [fowles] of the heaven) this indeed belongs to the Earth, and is hereafter to be handled in its place; the 2nd is [for] distinction cal'd Ætherial, from the Æther conceived to be more pure than our finest air, which fill[s] up all the Space between the heavenly bodyes and this heaven it is which we have now to doe with, and of this Somthing in General, and Special.

1st Heaven do birds; the 2d Stars possess
3d throne of God, Angels, and Souls do bless.

1. In General it was antiently defined a Simple body made up of matter and Cœlestial form. But as to the Simplicity, tis before laid aside, the Matter is now thought the same with ours, and the form parhaps not much unlike. The Affections ascribed unto the heavens ware formerly Greatest Tenuity, and Subtilty, yet pellucid Solitity (like that of Cristal) [incorruptibility,] round figure, with virtue and action upon inferior bodyes promoted by their motion, of all which some are now found to be mistakes, the rest figure influence and motion (being rightly understood) may be admitted and we shall anon Speack Somthing unto them. **[10]**

But 1st it will be here needfull to say a little of the Several Systems of the World as they have been diversely delivered to us, those are 3. that of Ptolomie, Ticho, and Copernicus.

1. Of the Old System of Aristotle, and Ptolomie which placed the Earth Quiet in the Center of the Universe with it[s] water, 3 regions of Air, and the Element of fire round about it. Then they thought that the heavenly orbs were round, hollow, Solid Transparent Globes, or Vessels containing Each other (like the Coats of an Onyon,) that most of their Imagined orbs had Some one part more dence than the rest that it might reflect light, which they called the planet of [that] orb, etc: That every [planet] had its distinct orb or Sphere to carry it about (like a nail in a Weele;) because they knew not else how to Solve the various motions which they had observed, and could give no other account of: Yea they Imagined Some orbs without Stars (as the 2 Crystallines, and the Primum mobile, or first mover) also to each of the Planitary Orbs they added Epicicles and other inventions in a most intricate, and perplext model, and all still to solve, the p[h]aynomina or appearrances rising from the Variety, and seaming Irregularity of their motions; they Gave also to each orb its Intelligence (or [Angell]) who was allwayes to Impel, and direct it according

to their [frame] in this motion of the Spheres diverse wayes; The Inner Surface of the one rub'd against the outward Surface of the next, and though very polite and Smooth (else the motion would have been hindered) yet made a noyes with Such an harmony as the musick would be admirable if it could be heard. They further say that (the Earth Standing still and looking on) the planets have 2 contrary motions, the One natural, and the other violen[t]. The Natural Inclination is from the west to the East; and they compleat their Circles round the Earth in Several periods of time (Called therefore their Periodical motion) the moon once in a month; the Sun with Venus, and Mercury once in a year; Mars in two; Jupiter in 12; Saturn in 30; The 8th Sphere (fill'd with many Stars fixed most whereof ar biger than the Earth, and Some many fold.) In 36000 years which great period they cal the platonick year[1] wherein all things return where they ware (You and I ware the last revolution here in this place talking about these Same things but when we two then dyed we drank of Lethe and So forgot all things as tho we had never been) and thus (according to Aristotles Eternal world) it will be again in the next revolution etc: Above this Great 8th Sphere, of fixed Stars, they have their Crystallines to Solve some approches of the Zodiack, and beyond all them is their first mover (or primum mobile) which (without regard or conformity to the other Great periods) whirls at no intelligable rate, quite about it[s] vast Circle in the [small] time of 24 hours, and this from east to West, by a Violent, (yet perpetual) motion, caryes with it all the Inferior and enclosed orbs, tho it has no hooks to fasten on their Smooth, and hard Sides, quite contrary to their natural inclination. And all these incredibles of the primum mobile are only to solve the diurnal motion, the rising and setting of the Stars, and planets which we dayly see, this is the old System.

2. The latter Hypothisis, (or Supposition) by Nicholas Chopernicus, about 150 years Since taken from some old hints of Pythagaras, and the Manifest absurdityes discovered in the Ptolomayik Hypothsis was thus proposed. Suppose the Sun in the Center of the Universe not moveing from its place but turning swiftly in it about its own Axis, to Spring or Whirle abroad (like a womans Mop,) its rayes of Heat and light in the world. The planets [he] Supposed Solid, Concrete, (and parhaps habitable) Globes the Earth he accounted among their number, (by the name of proserpina) all these receive the Suns light for their own Use, and reflect it (as So many moons) from one to another; the next to the Sun was mer-

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[1] The "Platonic Year," really not Platonic at all, was a favorite notion of the sixteenth and seventeenth centuries. The references in the *New English Dictionary* give an interesting brief history.

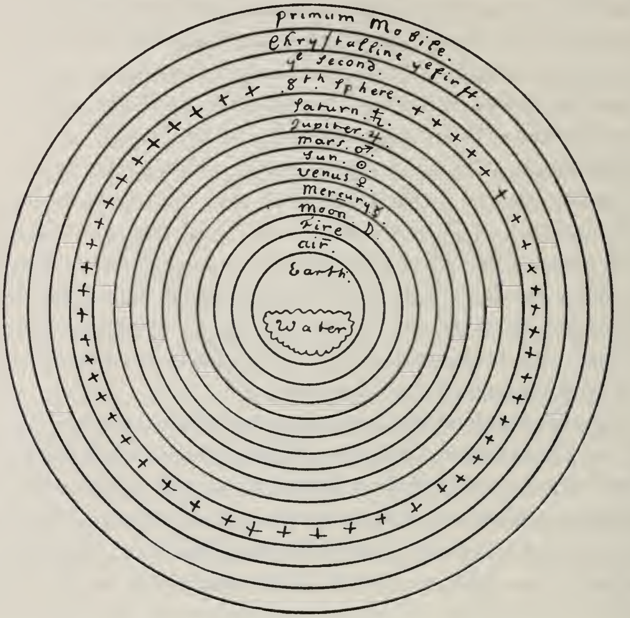
cury, who went about him not in a [Solid] Sphere, but free space (as birds in the Air, or fishes in the Sea) and the Same is said of all the rest. Next about mercury was the Circle of Venus, these 2 being near the Sun, reflect his light most vividly to us and their Circles being least they finish their Course in the shortest periods; about these next is the Earth, and the moon which goes round about it as 2 men holding hands may dance one about the other the one being as it ware the Center of the others motion. The Earth and the moon with it (at due distance) go round the Sun in that line which was before supposed [to be] the Suns anual march, and by its rolling round its [**11**] own axis in a tollerable Swif[t]ness once in 24 hours all the difficulty about the dayly motions of the heavens is Easyly Solved, and the Primum Mobile with its violent Whirle is discharged. After this new planet (the Earth, and its moon) the next is Marss, then Jupiter (with 4 Moons lately observed by the tellescopes) then Saturn (with one, if not 2 moons about him). all these are planets or Wandering stars changing their place and none of them has any light of his own but only that which it receives from the Sun. The fixed Stars, none of which Stir from their fixed place are above all the planets and are all luminous bodyes, as So many Suns in the firmament and that they appear not to us So great, and bright is only because of their distance.

This System proposed by Copernicus was about 50 years [Since] confirmed, and Illustrated by Galeleus; Approved after by Kepler; Dr Wilkings, and others most skilfull in Astronomy; only papists ware tender of declaring their minds too plainly in this matter; because the Pope (forsooth out of a private peek against Galeleus,) had from saint Peters Chair Condemned the oppinion this is very observable in the Ingeneous Gassendus.

3. The last System was by Ticho Brahe (proposed) a noble dane, who did nothing but restore the Earth to the center of the Universe: And then to solve the Appogees, and Peregees (Aproches to, and recesses from the Earth) he invented excentrices for the 3 uper planets, (or rather made the Sun their Center:) this he lived not fully to declare; It was followed for a whill by Some, and then began to grow out of repute; for Galeleus lived after Ticho, and discovered by his Glasses (which the other never knew) that Copernicus was rather in the right, and farther he shew'd, how it Solves [other] P[h]aynominas of nature, Especiall the Ebing, and flowing of the sea; the stated winds between the tropecks; the diurnall rising and Setting of the heavens, which before could never have any probable Solution.

I Shall not further enlarge on this matter nor insist on all the Arguments alledged to distroy the Old System of Ptolomie whose Sollid orbs must needs be broken by Marss his Somtimes approch to the Earth nearer than the Sun: Nor what Galeleus, Dr. Wilkins, and others Say to defend the Copernican Scheme, and how they answer those Scriptures which are alledged against his [motion] of the Earth, as being Expressions only Suited to [mens] Vulgar apprehensions and Sufficient for the Purposes they intended. What is said may suffice to Shew that the old doctrine of the heavens was imperfect, and that this latter seams more probable, and better suted to other things in nature, we shall have occasion to speak of hereafter this recommends it self to our acceptance as the most artificial for that it is the most Simple, and intelligible, and free from the other Intricacies as may be seen in the diagram.

The Ptolemaick ſcheme



Absurd and intricate the old is yet,
Tichoes imperfect, the Other is compleat. **[12]**

These things Supposed, 3 Affections of heaven [in Generall] remain to be spoken off, Figure motion and Influance.

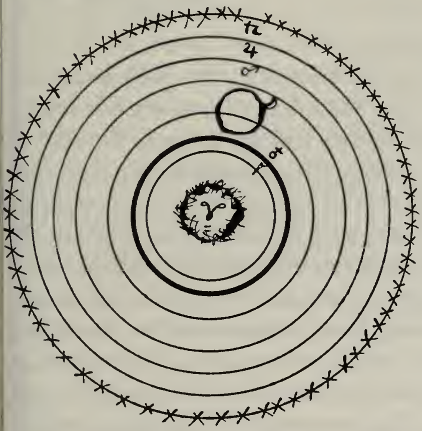
1. Their Figure is round, not an Orb, or Sphear to fix the Stars in but

all of them are Globular bodyes each having his place assigned by the Law of nature, and [that] without being fastened to any Sphere. This round figure is most fit for motion, content, and continuity.

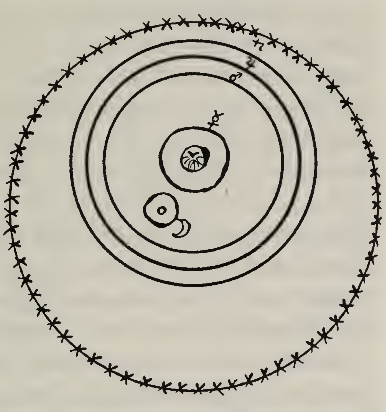
1. For motion round its own axis which every one of these Globes are Supposed to have; yea and progressive too; as, admitting the least impediment.

2. For Content of matter as being most compact containing the most matter under the least surface; (as appears in Geomitry.)

Copernican scheme.



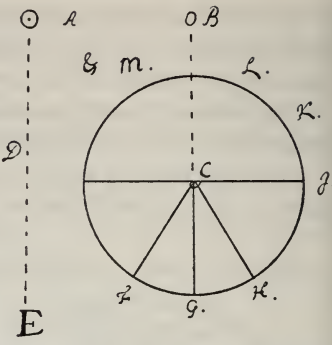
Tichoes Scheme



3. Continuity of parts, in that all of them hereby are in the nearest possible approach to their own proper center, and So their Unity, and adhesion is best secured by the General attraction natural to every kind of body.

In these round other figures do out-vie,
Motion, Content, and Continuity.

2. The Motion is Uniform, and Regular neither do they stray in the free Æther, out of their own course tho they have none of Aristotles intelligences to direct them. This Galeleus dos ingeniously Illustrate by a Supposition that each Globe of the universe was at first created at Some convenient distance from the place wherein; or the Center about which, it was afterwards, and continually to move, nor is this a harsh or improbable Supposal for if it ware perfected in one part of the circle appointed for its motion yet then it would be distant from the other parts thereof, and therefore it might as well be formed at a distance from the whole circle as from any part thereof. The thing may be thus explained by the Dia-



gram; as, Suppose (OA) be the Globular body of some planet created in that place at (A.) and the Circle (D.F.G.H.I.K.L. M.) be desighned for the Circle of its future revolution, whereof (C) is the Center: Supose also that it ware let fall when perfected from (A.) the place of its creation with command to go to the place of its designed residence not nearer to, or farther from the Center of its revolution than the Semidiamiter of that Circle (C. D) therefore it must needs fall in the pricked line (A. D) **[13]** as bodyes [use] to doe toward their proper center of Gravity; Now when it comes to (D.) it can no longer proceed in a Strait line towards (E) for then it would go farther of the Center (C.) than it is allowed by the aforesaid command or Law of nature; therefore it must then begin to turn about (like a pendulum) towards (F.) that it may keep its due distance: and having acquired velocity in its fall from (A. to D.) it continues the Same Velocity (to G, to H, to I, to K, to L, to M, etc:) and there being no natural impediment to hinder, it must continue the Same swiftness without Encrease, or Decrease, in continual repeated rounds in that circle forever unless stoped by a Supernatural Cause. How large the Circle of revolution shall be is according to the length of that distance which [it] is appointed to fall besides the Center or the length of the line (C.D.) How Swift its motion Shall be in that revolution is according to the length of the line (A.D.) If it must be very Swift; that line (or the Distances, of the places of Creation, and Residence) must be longer because by a Greater length it will accelerate into Greater degrees of velocity, and [then] at [last] hold those degrees which it has attain'd there being no impediment. This is Illustrated by the falling of a bullet from on high; for if in the first Second of time it falls one yard, In the next it will [fall] 3 yards, in the next 5, [the] next 7. [the] next 9. [etc:] Still augmenting its Velocity by the Odd numbers.[1] As to the turning round about its own axis it may be apprehended by the turnin[g], or running of a bowle. This has (you know)

Seconds of Time	Measures of Velocity
1:	1.
2:	3:
3..	5:
4:	7:
5'.	9:
6.	11:
7:	13:
	&c:

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[1] This is an admirable illustration of the bookishness of Morton's science. He points out that there is an arithmetical progression in the velocity of falling bodies, but he ignores the familiar and useful fact that that velocity is in definite proportion to the distance and the time of the fall ($s=\frac{1}{2}gt^2$).

2 motions; one Strait progressive to the end of the Green the other Circular about its own axis So that if (as in the [former] Diagram) the Globe (A.) be let fall to (D.) in a [trolling] motion, it will continue the same rolling round the line of its own revolution about the center (C) It remains only to Shew how the Sun in the Center of the Universe turns round it self without any line of revolution about another Center This is easy to conceive by Supposing it to be created at (B.) and then dropt in a troll, and determined directly to the Center, (C.) without any Such line of distance as (D.C.) for then when its Center is come to its appointed place (C.) it must there continue in the same troll it received when it was first droped. And thus much for the motion of heavens in General.

3. Influence and action on other bodyes, [by] light, Heat, or othe[r] communications is manifest both by Scripture, reason, and Experience.

1. By Scripture. *Psalm 19. 6. Nothing is hid from the heat thereof; Job: [38]. 31, 33. Sweat influences of the Plyades the dominion of Heaven in the Earth. 2. Samuel. [23. 4.] Like the tender grass springing out of the Earth by clear Shining after rayne.*

2. By Reason; Every body by motion and inward fermentations sends forth its Steames of Volatile parts, and that more or less continually; Somtimes more, when there is more Effectual cause [to] Excite them and more to [purpose] when their position is Such as that thereby they may be freer from obstruction in their Course or the better assisted or directed therein: Now Suppose the Moon (for Example) Sends forth cool [and] Moist steams. They are most excited in that part which is towards us, when the Sun is in opposition to it (as in full moon) Then also the rayes of light which are reflected from the moon come more plentifully and directly to us, and bring those [her] cold Steams with [them]; So that commonly after full moon we have cold, and moist weather. But when the Sun and moon are in conjunction (as in New Moon) the Sun draws these steams from us towards itself whence we commonly have dryer weather Soon after the new moon and So it is of the rest in their Several aspects; (Conjunctions ☌, Oppositions ☍, Trines △, Quartiles □, and Sextiles ⚹) to the Sun or one another [14] By which position they mutually either assist, or hinder their several Steams in coming toward the Earth. Now because these Aspects are never in all respects the same (unless after the Platonick [or] 36000.) hence may very well arise that great variety in the temper of the Air, Malladyes of Humane bodyes, etc: and yet the difference is not So great but that Eminent positions (as in their Several periods [they] do occur) may cause Effects much as they used to doe (as we see by Experience.)

3. By Experience, which tels us that a [Conjunction] of the Moon and Venus or Jupiter gives fair weather if there be any in the month, So cloudy with Saturn, [windy] and blustering with Mars. And of the Fixt Stars when the Sun or moon comes to them; there are observations of Certain and Usual Changes in the Air, and hereby their Opperations are direct or Indirect.

1. Direct, on bodyes which are altered in their present, and mutable temperament by these Steames; as in the Air, Meteors, yea Humane bodyes, deseases, etc:

2. Indirect on the minds of men by So affecting the body, and thereby promoting, or hindering the opperations of the mind; So Burton in his melancholly.[1]

—Thus much I find
Sick bodyes bread Sick passions in the mind.

Therefore it is that we are somtimes Quick, Active, Eager, and at other times Dull, Heavy, Melancholly, according as the Air (that perpetual Ambient Ingredient) is affected by these heavenly Influences.

Holy Writ Reason, and Experience,
Prove heavens Direct, Indirect Influence.

On this Affection (the Influence) is Grounded Astrologie which for want of Sufficient Observations to make rational inductions is therefore very Imperfect and uncertain in its rules; Dr. Beal[2] (tis said) advised the Royal Society that old almanacks were better to be written than new; meaning a Register kept of all Changes of Weather; that So a probable conjecture may be made of what will be, by a comparing of what has been already; which thing would be of Excellent Political, and Œconomical Use; then would Astrologie Gain a well Grounded repute whereas now as it is commonly practised, tis by prudent men thought folly; and by most Suspected [to be] knavery, and a Cheat.

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[1] Robert Burton's *Anatomy of Melancholy* was first printed at Oxford in 1621. It is comparable at many points with Morton's notions on physiology and related subjects, and even on astronomy, as is suggested in some of the notes below.

[2] John Beale (1603–1683?) was elected to the Royal Society in 1662–63, at a time when that body was much interested in making a history of the weather. On September 2, 1663, for instance, John Wilkins suggested that from constant observations it might be possible to prognosticate changes, and Sir Kenelm Digby remarked that Dr. John Dee, by such observations for a seven-year period, "acquired such a prognosticating skill of weather, that he was, on that account, accounted a witch." Thomas Birch, *The History of the Royal Society of London* (London, 1760), I. 300. A week later Mr. Oldenburg "mentioned, that Mr. Beal was willing to engage in the observation of the weather, and in registering the changes thereof; and that he hoped to set the same at work in other parts of the country." *Id.*, I. 302. The foremost investigator in this matter was, however, Robert Hooke, whose "Method for Making a History of the Weather" was printed in Thomas Sprat's *History of the Royal Society of London* (pp. 173–179) and, in part, in the *Philosophical Transactions*, No. 24 (April 8, 1667).

Old Almanacks would teach Astrologie,
But new are Stuff't with foolish knavery

For what reason is there in their calculating nativities that the position of planets at the moment of birth should So influence the whole life; yea other persons related to the party (as Father, Brother, Friend, etc:) yea and that forsooth according to the Houses (i.e. Certain Spaces of the Cœlestial appearing canopy whether above, or below the Horizon;) as if the Air ware so [very] differently affected by an hour or two's distance of time as that Honour or hanging depends thereon. What is there in [your] horary Questions, that the moment of asking should direct to the answer; as if the Stars which inclined the theif to steal inclined the fool just then to ask the Question, (Who is the theif)? when they intend to whisper the Astrologer in the Ear, and tel him the Ear mark which themselves have given him:[1] Mercury indeed is fabled for a Wagg but the rest are more sober and honest than to concern themselves in such intregues; I veryly think If any right discoveryes have been made in such occasions the Divel hath had a Greater stroack therein than the Art; thereby making way, and Animating these curious impertinents to become perfect wizards, Athists, Pagans and to think Slight[l]y of Gods providence. The like may be said of your assigning particular constellations and Planets to have dominion over particular countries, orders, and professions of men; Just as the papists have learned from the heathen Idoliters, So to distribute their tutelary Saints, as those did their Gods: and this may be a key to open the Mystery why some persons [were] so much inclined to apply themselves to Gadbury[2] they might as well have made Use of hamans [Pur][3] when he was about to distroy the Jews, to know how their plots Should Succeed. On the Whole matter I judge, that as to weathers, and temperatures of our bodyes with relation to health or Sickness by Good observations of prudent, and Phylosophycal minds, a Usefull knowledge might be framed; but for all the rest that is pretended the books written about them might make a curious bonfire according to the primitive pattern (*Acts.* [*19.*] *19.*) So Mr Gattaker,[1] and [Sir] Christopher Hayden of Juditiary Astrology,[2] and thus much for the heavens in Generall

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[1] Morton may have had in mind Anthony Griffin's *An Astrological Judgment touching Theft* (London, 1665).

[2] John Gadbury (1627–1704) was a notorious and immensely popular astrologer, one of the most colorful charlatans of Morton's time.

[3] See Esther, iii: 7.

Nativities horary Quest[ion]s are Evill
Stars ruling [countries] are all from the Divill **[15]**

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[1] Thomas Gataker (1577?–1654), a Puritan divine, became involved in a controversy about astrology when he published for the Westminster Assembly his annotations on Jeremiah x: 2: "Learn not the way of the heathen and be not dismayed at the signs of heaven, for the heathen are dismayed at them." In his *Vindication of the Annotations* (London, 1653), Gataker defended himself against the famous William Lillie; in *A Discours Apologetical* (London, 1654), he leveled a postscript at Gadbury.

[2] Sir Christopher Heydon (*d* 1623) was the author of a learned *Defence of Judicial Astrologie* (London, 1603). Why Morton cites him in the same breath with Thomas Gataker is not clear.

Chapter 5

Of The Heavens in Speciall

THE Heavenly Orbs in Special ware antiently distributed Into

- Without Stars
  - first mover,
  - 2 Christallines.
- With Stars
  - Fixt in the 8th Sphere,
  - Erratick Planets, Saturn, Jupiter, etc:

But not to truble you with this distribution; It may suffice to take notice of these with stars; (for the rest we have no sufficient reason) that is fixt stars and planets.[1]

1. Fixt Stars are those at Greatest distance from us, which do not alter their distance from one another, but appear still the same and in the same respective place (and parhaps Absolute too) they are distributed into Constellations and degrees of magnitude.

1. Into Constellations 48. Called by the names of Certain Animals whose shapes they are phancyed (with Dulness enough) to represent; however Custome hath so fixed this notion; that they are thus painted on our Globes. A more convenient way may parhaps be by referring them to certain Geometrical figures; or by dividing the Globe into Squares; with letters or numbers, as in some new maps is of late done.[2]

2. Into Degrees of Magnitude, commonly 6. but the Observers by the Tellescopes make many more; about 14 (as I remember) of these.

1. The Number in the constellations most [visible] are reconed 1022. and there are not many visible that are out of constellations. But there are Innumerable which for distance, or littelness appearring small, and Close set togather make but a [kind of] White mist or Cloud; [Such] is the Milkie way and other Such nebulous appearrances; from these rather than those that are visibly seen; are the stars even to a proverb called Innumerable.

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[1] Morton's information on stars and planets probably comes from some text-book. Legrand, *Institutio Philosophiae*, Pt. v, ch. xxiii, agrees with Morton that there are 48 constellations, 6 degrees of magnitude, and 1022 most visible stars. But Morton's table of periodical motions differs radically from the figures given by Legrand, as does his estimate of the circumference of the earth.

[2] This allusion appears to be to the Mercator projection, but it may be to some other of the many new projections which were used by experimentally minded map-makers in the seventeenth century. See Arthur R. Hinks, *Map Projections* (2d ed., Cambridge, 1921), p. 148.

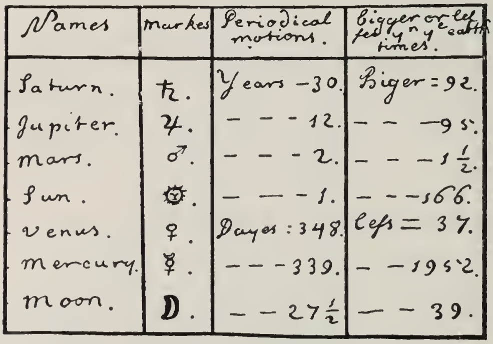
2. The light of these is native which visibly flames and Shines more than by only reflection of the Sun, as the Planets do and therefore they may be counted as So many Suns in their places

Fixt Stars in Constellations have degrees
Numbers, and Native light as each man sees

2. Planets are those that continually change their distance both among themselves, and in respect to the fixt stars; Of these may be observed Affections common, peculiar.

1. As Affections Common, their Magnitude, number, Motion and light.

1. Their Magnitude Various estimated by comparing [with] that of the Earth; whose Circumference is commonly accounted 21600 Miles,[1] [the diameter by consequence about 7000,] and therefore the Semidiamiter is about 3500; and this is the measuring rod, yard, or Pole, by repetition, or Multiplication of which the Stars magnitude is computed as you may see in the following table.



Names	markes	Periodical motions.	bigger or lesser yn ye earth times.
Saturn.	♄.	Years —30.	Biger = 92.
Jupiter.	♃.	— — — 12.	— — —95.
mars.	♂.	— — — 2.	— — — 1½.
Sun.	☉.	— — — 1.	— — —166.
venus.	♀.	Dayes : 348.	less = 37.
mercury.	☿.	— — —339.	— —195'2.
moon.	☽.	— — 27½	— — 39.

2. Their Number 7 according to the Antients whose [names and common] markes you have in the table.

N.B. These markes are known, and Used by all the learned of what nation soever. These and the Common marks of number[s], Weights, and Measures gave occasion, and Encourragement to the Attempt, to introduce a Universal Character thereby to Obviate or remove (if possible) the Babell curse, of the confusion of tongues But according to Copernicus the Earth (under the name of Ceres, or Proserpina) is [a] Planet in the Place formerly assigned to the Sun; and then the Sun is no planet but a fixt Starr in the center of the Universe. The Observers [by] Tellescopes have taken notice of and found out more planets, as two marching about Saturn

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[1] Legrand ("History of Nature," p. 81) gives Willebrod Snell's figure of 24,600 miles. Boyle, in *The Usefulness of Experimental Natural Philosophy* (London, 1663), says that the common account makes the circuit of the globe to be 22,600 Italian miles, which the "more accurate" Gassendus has amended to 26,255 of the same measure. See Boyle, *Works* (1772 ed.), II. 20. Burton, in his long "Digression of Air" in the *Anatomy of Melancholy*, gives 21,500 miles as the circumference; 7,000 miles as the diameter.

(Called his Ears) four about Jupiter (Called his Guard) But of these and the motions, Magnitudes, and Distances, and of Planets, the more full Enquiery is proper for Astronomy Here therefore they have but a breif mention Sufficient to explain the Nature of these bodyes.

3. Their motion is Circular in their proper line from West, to East which circle they accomplish in Various periods, as you may see in the Periodical motion of the table; hence they Change their places, and distances and hereby get the names of planets **[16]**

4. The light of them all except the Sun is none of their own but the [Suns] beams reflected by them; and hence the Various Faces, and Changes of the moon for so much of it only do we see bright as reflects the suns light towards us; as to the other small light [whereby even] in the Quarters of the moon, [we have] an obs[c]ure Veiw of the Whole body; 'Tis from diverse Causes, and in diverse parts giveing but a Secondary reflection;[1] as

1. That in the Middle is the Earths Moon shine upon it; i.e. the Earth reflects the Suns light upon it, and then it reflects the same light back again to the Earth, and hereby we see it.

2. That in the border or Edges; (or rather round about the body) which appears a Segment of a lesser Circle, than that part which shines in the old, or new moon; It is also the light of the sun reflected from the moons Atmosphere, answerable to our twilight when the sun is set this is not Seen in only the Old, and New moon; but also in the Ecclipse, as a ring round about when there is nothing but darkness in the middle of her body, for then the Earth can make no moon shine upon her having its dark side towards her. By the Tellescope Venus is seen somtimes horned as well as the moon, the other planets being farther of[f] than the Sun can yeild no such appearances; but must be alwayes fully Illuminated by the Sun, in that side of their body which is towards us; Hence also the Dark Spot (vulgarly cal'd the man) in the Moon for they are Supposed to be water, (the seas of that Globe) which being more diaphinous do drink in the Rayes rather than reflect them. thus we see it is with the windows of an house, which at a Distance seam darker, [or less] Illuminated than the wals wherein they stand. The Tellescope discovers other Spotes in the moon, besides these which are variable, and change their places these are but [the] Shaddows of mountains in the moon, which

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[1] The discussion of the light of the moon is paralleled in Legrand, *Institutio Philosophiae*, Pt. v, ch. xx, where it is attributed to Galileo. There is some possibility that Morton knew Galileo's writings, either directly or through the English translations in Thomas Salusbury's *Mathematical Collections* (London, 1661).

cast their Shaddows variously, as the Sun shines on them, and this is that which gives occasion to Some to think the Moon (and parhaps other planets) are habitable as our Earth is.

Lastly from this borrowed light do arise the Several, and peculiar affections next to be spoken of.

With 4 things Common planets are affected
Magnitude, Number, Motion, light reflected

2. As Affections peculiar to the Sun and moon are considered the Ecclipses which are obstructions of the Suns [Luminous] rayes by the Interposition of an Opacous, (or not transparent) body. It is two fold Solar, and Lunar.

1. Solar, when at new moon, the moons body is directly interposed between the Sun and our Eye whereby its rayes cannot come directly to us. It is a full ecclipse when the interposition is Central; but it is never total, because the moons body is less than the Earth.

2. Lunar, when at full moon the Earth is at like position between the Sun, and the moon; whereby the Earths shaddow falls thereon, and keeps of[f] the Suns light from it. This may be total (when Centrall) because the Earths body is bigger than the moon.

N.B. Those Ecclipses would be every new, and full moon ware the moons circular revolution, directly under the Suns, (or Earths) Eccliptick; for then at all such times there would be a Centrall interposition; but 'tis not so; as Experience and astronomy teaches us; 'tis only at certain times; which the Astronomer that knows the Moons course, can foretell; hence the Uses of Ecclipses are admirable.

1. In Chronologie; to know the true time of Hystorical action when an ecclipse is noted by the Historian to be at, or near the time of that action; for the Astronomer can soon tell; if there ware such an Ecclipse at that time.

2. In Geography; to settle the true longitude of places; for by calculation they can tel at what hour and minit the Ecclipse must begin and End in this or that longitude round the whole Earth.

3. The Earths magnitude is hereby [truly] known, for Geometricians can by a segmen[t] of a Circle given quickly find the whole circumference, and thereby the true Diamiter, and Semidiamiter.

4. And so Astronomers have gotten a measure for the planets their Distance and then by consequence their magnitudes. besides the Certainty wherewith they are Satisfied that they know the true motions of the Heavens; for otherwise they could never fore tell [those] Ecclipses so

exactly as they doe. And thus this little shaddow gives light to many Eminent parts of learning, and therefore we may [say] that for these (or such like) noble Ends did the wise creator command this p[h]ainominon in nature, but for those prodigious Effects which astrologers are [17] pleased to ascribe unto them; they are Idle conceits by no wise man to be regarded.

Ecclipses Solar, Lunar, have their Use,
In Science; In Astrologie abuse.

And thus we have gone through the Heavens so far as concerns natural Phylosophy, and now we come to the other Species of bodyes Viz: Terrestrial, of which in the following Chapter.

Chapter 6

Of Terrestriall Body, and of the Elements in Generall

BODY Terrestriall is either Simple, or mixt.

The simple are cal'd Elements, which are the material constituent parts of all other bodyes[1] these ware commonly accounted 4, Fire, Water, Earth, and Air. thus Aristotle. Cartes makes 3 matters which he denominateth of the 1st 2d and 3d Element.

1. Crasse matter (cal'd matter of the 3d Element) is that (sais he) of which all Terrestriall bodyes are made.

2. Tenuious, Subtile Globulous, Coelestiall matter (cal'd of the 2d Element) of which he supposeth the Sun, and fixt stars, as all luminous bodyes to be made.

3. Most tenuious, or [most] Subtile the strait matter (of the first Element) of this he makes [not any] body at all, but will have it imployed to permeate all other bodyes to fill up all the pores, and vacuities between their minute parts, and so to further their motion without a vacuum.

Gassendus and other Atomists will have but one kind of matter for all things (which they call corpuscles or little bodyes) which (say they) are variously shaped, and have between them little vacuities or Empty pores (vacuums Interspersed) these they say may, yea must be allowed for the help of motion, that being unable otherwise to be performed. Chymists say there be 5 Principles (Elements, or Matters) of body for so many by art of fire they can Seperate, and make Sensibly distinct, namely, Salt, (which fixes) Water (to moysten) Sulphur, ([oil or fat] which is apt to flame) Mercury, or Spirit (which is apt to fly away) and Earth (to dry). Other Chymists will have but two Elements namly particles; Active and passive.

1. Active, which are Salt, Sulphur, and Mercury.
2. Pasive, which are Water, and Earth.

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[1] The description of the elements goes back to Aristotle's *De Generatione et Corruptione* and *Meteorologica*, while gravity and levity are treated in the *De Caelo*. The same matters are considered by Descartes in *Principia Philosophiae*, Pt. IV. This chapter is most closely related, however, to Boyle's famous book, *The Sceptical Chymist* (London, 1661), where Morton may well have found his information on the chemical theories of Descartes, the "Chymists," and "Gassendus and other Atomists." A number of points seem to suggest some knowledge of Boyle's "History of Fluidity," in *Certain Physiological Essays* (London, 1661). There, for instance, are to be found a discussion of the nature of fluids and the experiment, which Morton mentions on another occasion, of the two flat polished marbles.

4 Antients Elements, 3 now will doe
Atomists [one], Chymists some 5, some 2

These things premised, let us take a Veiw of what the Antients say of their 4 Elements, which they Usually consider in order to their deffinition, Absolutly, and respectively.

1. Absolutly, and So they define an Element a simple body made or composed of Elementary matter and Form. So that [they] make it a Compound tho not a mixt.

2. Respectively, in Order to mixt bodyes, and So Elements are body[es] out of which all bodyes mixt are composed at first, and into which they are at last resolved; but they are not resolvable into any former bodyes that are Specifically distinct from themselves.

N.B. Therefore (Say the Chymists) they are 5 for so many can we resolve a body into (as is before noted).

After the deffinitions follow the Affections in General {Absolute,
Respective.

1. Absolute are such as appertayn to them without respect to any other body; as Elementary Qualities, and these either 1st or Second.

1. First Qualities which are primary in them and they are either {Active,
Passive.

1. Active are heat, and cold.

1. Heat, a Quality congregating (that is gathering togather) Homogeneals, (that is bodyes of the Same or like name and nature,) and segregating (that is seperating) Heterogenials (of diverse nature) thus metals of diverse lumps melted by heat do [run] into one. So also in the burning of Wood the Sulphurious and watry [parts (being in Some respects alike) do fly up together in the] Smoak driven up by the heat, whereas the Earthy and Saline (being [congeniall] one to the other) do fall down into the Asshes.

2. Cold on the Contrary congregates Heterogeneous, as well as [Homogeniall] bodyes; So wood, Water, Stones, etc: are all by [cold] compacted into one lump of Ice, which Heat will again soon make to fall asunder.

2. Passive are moyst, and dry.

1. Moist Humidity (or rather [indeed] fluidity) is a Quality whereby a body is easily contained in the bounds (or hollow Surface) of another body, and with difficulty under its own, So Water is Easily kept togather in the hollow Surface of a Glass but Spatters abroad if cast [forth] on the floor.

2. Dry, Siccity, (or rather Solidity or stiffness.) whereby bodyes (on the contrary) are easyly contain'd in their own surface hardly in anothers as a Stone that will not conform its self to the shape of a Glass.

N.B. That Humid, and fluid are mention'd to be but one Quality yet they seam to be very different; for a thing may be dry and yet frely flow, as the sand of an hour Glass. The only answer in the case is that Sand is not one body Except by Accident **[18]** as all aggregates, and heaps are; but the present distinction concerns bodyes that are one directly, (as Water) and not by accident (as Sand [is]). thus say the Aristotelians. But the Atomists will have all fluids to be but heaps of round particles which by that figure have an Easy motion; thus powdered plaister of paris will boyle like milk.

first Qualities of Elements do lie,
In active Hot [and cold]; passive, [moyst], and dry.

2. Second Qualities of Elements are those which are said to arise from the 4 first, which do affect only, or affect and move.

1. Those that do affect only without motion, [or] do not from their own nature cause the motion of a body. Such as these opposite paires. Density, and Rarity, Crassitude, and [Tenuitude], etc:

1. Density, and Rarity; a body is Dense that is full of its self, or that is compact having few or small pores; or, has much matter in [little] Surface. So Gold is said to be most dense. But Rare is to be very Porous having little matter in much Space, as a Spunge, or Cork.

N.B. Rare is there taken Phylosophically not as Vulgarly for that which is scarce.

2. Crassitude, and tenuity. By Crass, or Grose, understand (not as Vulgarly a big, thick or fatt body but,) that which is unapt to enter into the pores of another body, and on the other hand tenuious is (not Slender, but) that which is apt to enter into pores, as all fluids are Generally; So the rayes of light pass through the strait pores of Glass; how soever small they be; and So Fire insinuates [itself] into the least Pores of the most dense bodyes; as of Gold when it melts it: And thus we see Air More tenuious than [Water], and fire than Air because it can pass [where] the other cannot.

3. Hardness, and Softness; Hard yeilds not to touch as Soft bodyes doe; So when wax is heated it yeilds to impression but not when [it is] cold.

4. Toughness, and Brittleness, this is fragile having parts easy to be Seperated, but that not So; having parts Strongly adhearing togather. Now these are said to come to pass partly from the position, partly from the figure of [the] particles, whereof the body is composed, for suppose the minute parts [are] luminous (i.e. of Plain, and flat Surface) these will stick Close togather as we see in Greater bodyes; Two flat marbles ex-

actly pollish'd, and laid plain, to plain may be easily slipt apart; but hardly by any force pul'd assunder; because then there would be a vacuity in the middle; ere the Air coul[d] rush in from the sides to fill it. So if the minute parts be [hamated], ([i.e.] hooked) as burs they must [needs hitch the one] in [the] other which if intermingled with parts apt for fluidity it makes that which we call Clamminess; as in bird lime, etc: So if the particles are Straited (or long) and these interwoven traverse or wreathed they will hold togather; as we see in the Wool of yarn, yarn of Cloath, Splinters of wood which [we may] observe in the cleaving thereof with a Wedge.

5. Elasticity (or Springiness) and flexableness so as to stand bent; the difference we see in steel, and lead. The reason of Elasticity by Dr Petty is Judged to be a magnetick virtue in Each of the particles whereby they incline to stand in a line so as their amicable poles may touch each other; and therefore if they are removed from that verticity they will of their own accord [recurr thereunto]. I know not a better Solution of this P[h]ainominon more of this after in the Chapters of air and metals.

6. Aridness which hinders motion and Sliperyness which promotes it; Hence we apply Oile or Grease to Wheeles, the Oily particles being round do truckle under weight, as pease scattered on the floor may Give a man a fall; these and other such like 2d Qualities are ascribed by the Antients to be derived from the 4 first Qualities of Elements. but latter men do chuse rather to solve them mechanically by the figure, and site of the matter or particles of the body[es] to which they do belong, as is before explained concerning some of them.

2. [There] are [other] 2d Qualities which are said by the Antients to affect and move, of which kind they only mention 2, Gravity and levity.

1. Gravity is a Quality (say they) arising from cold cheifly and causing bodyes to discend or tend towards the Center this they call Gravitation an Endeavour, or Inclination to be as near the Center as it can; and this without an Impediment is alwayes in the strait perpendicular line.

2. Levity on the contrary assend[s], and is Cheifly from heat; but this is no wayes [allowed] by latter phylosophers who assert that all bodyes are heavy or tending to the center of the Globe to which they do belong, and that this is obedience to the law of nature, as is after noted in Locomotion, [so] that all motion upwards is (not by tendency but) by Violence [and] pressure, as may be seen in the discourse of Sinking, and Swiming and [there] it appears that those bodyes which are called light are only less heavy than their neighbours by whom they are poysed up; this is manifest in a ball of wood drop't from on high into water; for it discend[s] in the air, because heavyer than that is and So proceeds to the bottom of the

water; because of the Violent Velocoty acquired in the aforesaid discent; but when it comes to the bottom, it Stayes not there but ascends to the Upper Surface of the water because the water is heavier than the wood; and yet the wood is never the lighter for this ascent. [**19**]

Gravity [is] an attribute that moves,
Downward; and Levity that upward loves

N.B. To this Kind of affections may be referred Elasticity (before mentioned) Magnetism and Electrical virtue[1] all which do also cause motion, but of these after in a more proper place.

And thus much of these cal'd absolute Qualities.

2. Respective Qualities of Elements are accounted by the Antient[s] 2 figure, and Mutual transmutation.

1. Figure (as respecting the Universe.) round; this they say is natural though some Elements by Accident are varied into other figures; which may be thus explained. If the body of the Earth ware reduced into small sands, they would not stand up in mountains and hills, but endeavouring all of them to be as near the Center as possible would necessarily fall into an Exact Globe; because then all its parts would [be] in the nearest possible access to the Center. then would the Water which is less heavy than the Earth flow everywhere round about it, then the Air about the Water, and lastly the fire about the Air (according to the old hypothisis.) And thus would all in round figures (at least as to their exteriour surface) compleatly fill the hallow surface of the Imaginary orb of the moon. But by accident it is otherwise in Earth and Water; for to provide dry land for terrestriall animals; Rocks (as bones) ware created to hold up the Earth of the Hills above the Water, and so both the upper surface of the Earth, and the neather of the Water do become uneven. Drops indeed of water [are round] but it is not So much from the nature of the Element as from the nature of a fluid [endeavouring] to hold its continuity; for hereby it [is] obliged to flow as near as possible to its own proper (namly the drops) center; and therefore by consequence into a round figure, (as is before noted)

2. Mutual transmutation by which they respect one the other, and are Changed one into another. This is (say they) either,

1. Social; which is when two Elements club to make a 3d as when fire and water are turn'd into air, (this they supposed to be in the Evapporation of water) but indeed this is a common mistake for the Water is but

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[1] The word *electrical* is here used in an obsolete sense; as Mr. Morison has noted, Morton in Chapter 10 uses *elatery* instead of *electricity*. See under these words in the *New English Dictionary*.

devided into lesser parts dispersed, and carried away else where; but remains water still.

2. Solitary when one Element is turned into another (as much to be doubted as the former.) This is either mediate, or Immediate.

1. Mediate when one Element is transmuted by the mediation of another; as water into fire by being first turn'd into Air. And Such are called Dissimbolics that is which agree not in any of the 4 Qualities for fire is hot and dry, Water cold and moist.

2. Immediate turned Immediatly; these are Symbolics which have some one of the first Qualities common between them thus Air and Water agree in Humidity etc: But indeed all this of transmuting Elements seams to be but Goats wool: for there is either no such Change, or if there be, they are neither simple bodyes nor Elements for this warrs with their former notion in the Deffinition of principles where they say that they are neither made of one another, nor of any other bodyes, Now Elements may well be accounted principles, and this may Suffice concerning Elements in General.

Chapter 7

Of Elements, in Special, and First of Fire

ELEMENTS in Speciall (according to the Perepateticks) are 4—

Fire
Water
Earth
Air.

as was collected (say they) by Aristotle from the combinations of the four first Qualities; So as there are two of them in Each Element, one in the highest the other in the remiss degrees; thus fire is most hot and dry; Water most cold, and fluid; Air most fluid and hot, Earth most dry, and cold.

Elements number Aristotle spies
In combinations of first Qualities.

About this distribution are moved many controversies; for some say fire (in its flame) is more fluid than Water, and in its body more dry than Earth; Air in Winter is more cold than Water: and Earth too (it seams) is more cold than water because more hard (for it is a received oppinion even among aristotelians that coldness is the Cause of hardness, as in Ice,) and if the air be made more cold in Winter, than water, by nitrous particles arising from the Earth then is the Earth the coldest rather than water.—But indeed in all this matter men feel in the dark; because they acknowledge no pure Element falls under our observation; how then can we make a Judgment of their first Qualities Natural to them and distinct from [those] accidentially in them. Besides they all confess the forms of Elements are not known, and therefore they [20] say they must be defin'd by their Properties or first Qualities but how shall we know what are their first Qualities; till we know the forms from which they should immediately flow. Therfore (to avoid this confusion) latter Phylosophers refer the whole business to matter variously modified; and disposed; and so they define them.[1]

1. Fire (according to the Antients) is an Element most hot, and dry. here they mean (not our culunary, or ordinary kitchen fire which is a concrete body but) that which is fancied above in the concave of the

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[1] In this chapter again the chief influences are Aristotle and Boyle, with the *De Generatione et Corruptione* and *Meteorologica* on the one hand, *The Sceptical Chymist* on the other.

Moons orb; which they say dos not burn as ours, because of its tenuity whereas to burning is requ[i]red some Crass matter, whereby it may better adhere to the body to be burnt. hence a Cole, or Hot Iron burns more than a flame especially the flame of a tenuious matter; as, of Spirit of Wine, which if highly rectified is alltogather Innocuous. thus the fire of the Antients.—But (according to the Moderns) fire is matter briskly moved; therefore to kindle Such a fire is to beget Such a motion. And to continue it is to supply it with matter apt So to be moved. Matter moved briskly causeth attrition, or rubing of the particles [one] against another; [this causeth heat,] which continued, and intended becomes fire apt to communicate the like motion to particles of other bodyes. This Motion is helped by the blowing of bellowes, or other Strong wind thrusting the particles inflamed among the enflameables of the fewell and removing the Ashes which would obstruct the briskness of the motion. thus they solve the Striking of fire by flint and [steal], and the catching thereof by tinder. Also the kindling of fire by a burning Glass collecting diverss rayes of the Sun to a narrow space, where they rub each other and cause this motion; Also the Inflaming of Wett hay by putryfaction for the Volatile parts of the matter being restrained by the moisture are stirred more Vehemently to break out, for which when they found a Passage they become a flame.

Matters brisk motion fire hereby put on,
Fewell, Wine, flint, Glass, Put[r]efaction

Now because this motion cannot be continued without a Succession of Air to follow the moved parts; therefore fire is Extinguished by hindring this Succession; as the putting an Extinguisher over a Candle; Stoping the top and bottome of a Chimney; laying Wood or Coals too Close; or Heaping to much fewell on a [small] fire, or by the Pneumatick Engine (or Air pump) when the Air is Evacuated.[1] In General whatever is apt to stop this motion dos Extinguish fire; as for putting out fire in the stem of a Chimney fired, by shoting up a Gun; by pulvis fulminans, or the Cracling of Salt; as also the blowing out of a Candle; tis done by putting the fiery particles into such a motion (onwards) as thereby they are Seperated from the Combustible matter Lastly Water (in a Sufficient Quantity) for that its parts are not apt to take this motion, and therefore do hang in the way of those parts that are apt to be moved: but if it be but little, and the fire overcome it, to Rarefaction then does it move as the Air dos, and so is Subservient to the flame; as we see in the Smiths Coals, and Green ash wood.

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[1] This allusion suggests some knowledge of Boyle's experiments with combustion, described in *The Relation betwixt Flame and the Air* (London, 1672).

Extinguish fire by Stoping motion
Blowing of flame, and pouring Water on.

2. The Species Sensible of fire are actuall, and potential.

1. Actual [fire] is again either Coale, or flame.

1. Coale or Solid body that seams to hold fire in it, is Such as has its volatile or motive parts restrained by Some particle[s] of other figures; Hereby the fire seams to be within it; but indeed there is only a little flame round about it, caused by the motion communicated to the adjacent parts of Air. Herby we see it luminous in the Surface but we cannot see into it as is manifest in [a] red or White hot Iron.

2. flame is where the Moveable parts are more free and can vibrate themselves more outward in the Air. Of this consider the Matter, Affections, [and Effects].

1. The Matter inflameable, is fatty, Sulphurious, Oilly, or Resinous.

2. The Affections are light motion, and adhæsion.

1. Light caused by flame is because of the motive parts thereof who can sufficiently Vibrate themselves, to give Vibration to Luminous particles (wherewith the Air is fil'd) that they may also vibrate the fine Spirits of our Eye (seated in the Optick Nerves) So as that our Souls may perceive their motion; (Hence in the dark by a blow on the Eye a Spark, flame or light appears within because of a lik[e] motion in those Spirits) this Vibrating motion is in Strait lines the continuance of which being intercepted by any other dark body begets a Shaddow which is a partial privation of light; as Darkness is a totall: that is a Cessation of Motion in parts apt to cause light if they ware duly moved. And if a Greater light appears; it Swallows up the less; snatching the motion from it to itself; Hence 'tis that the Sun puts out fire when it Shines strongly on it; and we cannot see the flame **[21]** of a candle in a Window when the Sun dos [brightly] shine. So that flame may hence take this deffinition, fire causing light.[1]

2. The motion [of] flames tenuious parts is upwards by the pressure of some more heavy adjacent bodyes; So that it would Emerge, (like Cork put to the bottom of Water) [to] the uper surface of the atmosphere at least ware it not for its natural adhæsion to somthing here below. therefore

3. Its adhæsion by the bottom to some more Solid body is only a re-

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[1] Compare pp. 155–157, below.

ceiving a continued Supply of inflameable parts the which once Spent the flame vanishes.

3. The Effects of fire (besides heat, and light mentioned) are various, and of great use for the service of men: Seperation [Denigration], etc:

1. Seperation of Heterogeneous parts whereof some { are carried above it
fall below it.

1. Carried above it as Smoak or steam, a Mixture of lighter, or more volatile parts of Water, Salt, and Sulphur, which were before in the composition of the body burnt. Smoake makes Soot in the Chimney; and Steam is the Ground of distillations.

2. falling below it are Ashes, and mixture of Earth, and the fixed Salt.

2. [Denigration], or making black; by peirsing multitudes of Small holes in the Surface of the body whereby it drinks in light, and reflects it not; for black is but the privation of light reflected as we may see in the hole of any wall which appears black.

3. [Exsiccation], or [Drying] by the Evaporation of the moisture; that is, giving the Watry particles motion enough to be gone from the body though not inflamation, [of which] they are not capable.

4. Induration or [hardning] (by consequence) of Such bodyes whose Softness is from moisture; as Clay.

5. fusion or melting by Insinuation into the body of metals, and putting their inward particles into motion which when it Ceases, leaves the parts in Quietness, and the body to hardness again.

6. Vitrification, (which is [the] utmost fusion) or making of Glass 'tis by removing the Heterogeneous earthy parts from those which are apt to flow (or melt) and in flowing [to] adhere (or stick Close togather).

7. Elixation, (coktion or dressing meat) is removing Such crude parts as are unapt for digestion and nourishment.

8. Refocillation, (or Cherishing the body) in cold seasons by putting our natural Spirits into convenient motion, for opening the pores, and promoting a due circulation of the blood, by melting the Clods thereof (Especially in the Extream parts, and capillary vessells)[1] whereby the offensive [Steams] are Ejected, the Spirits Quickned, and dispersed through the whole body. And thus much of actual fire.

2. Potential fire is that which dos in it Self appear to the senses not to have any resemblance of fire, yet has many of the powers thereof manifest in the Effects; as burning Fermentation, (or Heating,) Ebullition (or boyling) and sending up fumes. Now Such bodyes, are Certain, Sharp or

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[1] As Mr. Morison has noted, Morton here reveals his familiarity with the work of Harvey, Malpighi, and Leeuwenhoek.

acid Salts, which have Volatile parts put into vehement motion by humour or Liquor (as Lime) or by the Salts of Some other bodyes, apt to work upon them; for their burning or fermentation is alwayes by mixing of Somthing heterogeneous; and this commonly is a Solution, or Liquor for if the Salts are dry or unmixt, their parts are Quiet, and have no such Agitation. Thus the Salt of a Minerall, and Vegetable mixt (as Spirit, and Tartar, and [Vitriol] put togather) will Cause Ebullition, and a Great fervour in the Liquors, which to touch are otherwise naturall[y] cold. And thus much of fire.

Effects produced by fire potential,
Make real fire though like it not at all.

Chapter 8

Of Air

AIR is (by the Antients) an Element most Humid, and Warm its motion is upwards; its place between fire, and Water; and this divided into 3 regions.

1. The lower region which begings at the Earth or Water, and reaches up to the place of the Cloudes, because so fare the beams of the Sun are more Strongly reflected from the Earth whose steame they cary with them to be the matter of the Clouds.

2. The Middle region which from the Extent of the lower region reacheth to the top of the Cloudes: this is said to be the coldest of the 3 for a 2 fold cause privative, and positive.

1. Privative because it is so far from the fountain of heat that many rayes springing from that body do not reach it, and So far on the other side from the Earth that the reflected rayes [22] of the Earth do not assend unto it.

2. Positive and that (still according to the Antients) $\left\{\begin{array}{l}\text{Directly.}\\ \text{by accident.}\end{array}\right.$

1. Directly, the cold Vapours that are by heat lifted up; but then returning to their native cold they cool, and Chill the Air that is mingled with them.

2. By Accident, the Antiparistasis, (a [Greek] compound word, hansomly Signifying, natures Strugle, or contranitence against what dos oppose it;) for as nature ordinarily opperates according to the Utmost of its power, So does it much more, and Especially when it is to conquer a difficulty. Thus Fire beseiged with cold in frosty weather Scorches more vehemently having its heat thereby intended: and [by] like reason the middle region of the Air being beset on both sides (both above, and below) by those warmer ones, has its cold between them intended also. The Vapours, (I suppose they mean those which are naturally cold) have their cold strengthened; as the hot vapours also by this neighbouring cold are heightened somtimes even to a flame. And from these reluctancyes is the Generation of meteors in this part of the Air (of which after) Whether the Air it self have any native cold may well be doubted as contrary to their [own] deffinition of Air.[1] These 2 Regions togather are called the

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[1] Although there are hints of the *De Generatione et Corruptione* in Morton's treatment of

Earth[s] atmosphere whose extent is variously assigned: Some say tis 3 miles of perpendicular height from the Earths Surface, some 4, some 7, Some more; [Tis not far above the Topes of higher mountains, Some Say;] It may not be So high, Say others; Olympus is said to have its name from (ὁλος λαμπρος) wholly clear without clouds, they mounting not so high. A Part of the Alps near Padua is said to have a hill where men ascending, have Gone from great heat at bottom, through Snow in the middle to dry land at the top, where no rain nor dew comes, and therefore no Vegitable there to be seen. but below them they have observed thundring lightening, and great Stormes whereas themselves have not felt the least motion of the Air. And the like (in the Phylosophycall transactions) is said of the pike of a Teneriff.[1]

3. The Highest region of the Air is from the hig[h]est of the Cloudes, to the Element of fire (as they speak according to the old hypothysis) which is so tenuious and thin that it is unapt for men to breath in; and therefore those assenders to the tops of those highest hills (before mentioned) ware forced to carry moisted Spunges in their teath, that thereby the Air might be qualifyed to the necessity of their natures. This region is said to keep its quantity of Extent whereas the other 2 do vary it; for in Summer the lower is biger, and in the winter less giving to or taking from the middle according to the strength, or weakness of the [Suns], reflexion, (or rather according to the more direct or oblique reflexion of the sunbeams;) for direct reflexion riseth high, as [is playn] in a boyes ball thrown directly against the ground (the Angle of incidence and the Angle

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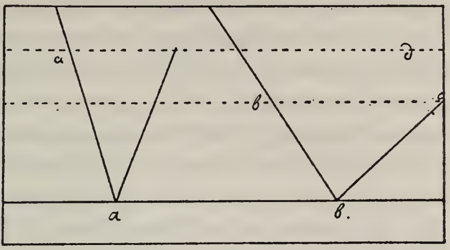
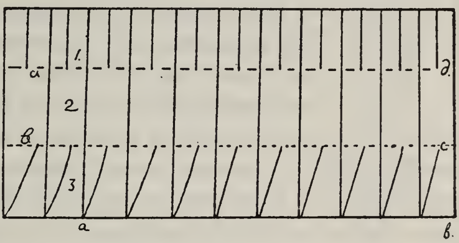
the air, he is more largely indebted to Boyle's *The Spring and Weight of the Air* (Oxford, 1660). There one may find some discussion of the height of the atmosphere, the use of the word *restitutive* to describe elasticity, and the analogy of wool; consideration of air-pump experiments and of what happens in rarefaction (not accepted by Morton, who will not give up "nature abhors a vacuum"); some treatment of the weight of the air; and a description of Pascal's investigation of the effects of altitude on barometric pressure. Indeed, this whole chapter is saturated with Boyle's ideas, even though Morton retains the ancient division of the air into three regions, of which the upper and lower were thought to be hotter than the middle. Boyle had refuted this Aristotelian concept in "An Examen of Antiperistasis," a portion of *The Experimental History of Cold* (London, 1665).

[1] Here Morton's memory seems to have been in error; at least the editor has not discovered the relation referred to in the *Philosophical Transactions*. From the first, however, the Royal Society was much interested in the famous peak of Teneriffe, proposing experiments to be tried there, collecting accounts of it, and inquiring what time of year was best for climbing it. See Birch, *History of the Royal Society*, I. 8–10, 18, 397. One account was printed in Thomas Sprat's *History of the Royal Society*, and another in Robert Hooke's *Lectiones Cutlerianae* (London, 1679), the latter being a book used by Morton for certain points in Chapters 13 and 21. In both cases, however, the details are in some respects different from those given by Morton.

of reflexion being the same) See this in the diagram; for Suppose the Discendent ray (or ball,) passeth in the line (aa) it will rise as high as the pricked line (ad.) (thus in the summer) but if it discend by the line (b.b.) it will rise no higher than the pricked line (b.c.) thus in the winter this determines the Quantity of the lower region which in the Summer is as high as (a.d.) but in the Winter only as (b.c.)



Now to Explain why the middle region is most cold; you may Suppose that some rayes of the Sun do not reach home to the Earth (a.b.) but only So far as the pricked line (a.d) Other[s] again come down and smite the Earth (a.b.) and rebound as farr as the line (b.c.) Tis manifest the num[b]er of rayes are double above (a.d.) and below (b.c.) [to what they are between (d. and c.)] therefore the upper region (1.) is hotter by the double number of direct beams, and the lower (3.) by half direct, and half reflex. but the middle (2.) cold because it hath but half the number of the other.



Extreams are hot but cold the middle is
By Vapours, rayes want, Antiperisthesis.

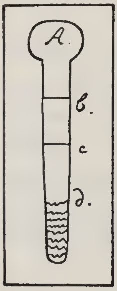
The Affections of air are absolute or respective.

1. Absolute affections such as appertain to it absolutely considered without respect to the mixtures in the Atmosphere, these are 3, Fluidity, Elasticity, and Weight.

1. Fluidity or Easy Seperation of its parts which have no cohæsion, at least [much] less than water (as we before noted) and hence that aptness to receive into it Heterogeneous bodyes, Such as rayes of light; Steames of the Atmosphere; and Evaporations from particular bodyes that give a scent pleasing or offencive.

2. Elasticity or Springiness cal'd power Elastick, or restitutive, whence an apt-[23]ness to return to its due Extension, when either the parts are pressed togather, or Stretched assunder beyond their natural State. Illustrated by a pound of wool which is capable of being thrust into a Quart pot; but

when freed of the compression, will of its self expaciate to its former bulck: and (on the other hand) any Curled hair of wool, may be drawn out to a greater length, than Usually it stands at; which when discharged of the force will shrink again into its former posture. So it is in the body of Air; this compression of air is call'd condensation, because then it has more of matter in less space; and its contrary distension, is cal'd Rarefaction because it has less of the matter in a greater space; But what fills the Vacuity[es] between the parts in Rarefaction, in such cases where no sensible suply is to be perceived is a great Question; as for Instance; Suppose in the Thermometer, or Water-Weather [Glass] the Water stands at (c.) the warmth of the air, or ones hand laid at top will presently bring it down to (d.) hereby the Air in the ball (A.) is rarifyed; now are the parts of it at greater distance each from the other, what is between them must be either a vacuum, or it is Ætherial, [or] fiery matter, that can Easyly permeate the pores, of the Glass to avoid a Vacuum; and so again when by Cold the Water assends to (b.) the matter that filled [the] Spaces must find the way out, as it found the way in, or there will be in the condensation of that air in the ball, a penetration of dimensions; which is impossible I rather therefore Chuse the latter; namly the permeating Matter, because nature abhors a Vacuum: The force of this sp[r]ing of the Air is great, as appears in Wind Guns, and Artificial fountains, formed on this foundation; as also the lifting of weights by an half blown bladder in the Evacuated vessell of the Air pump.

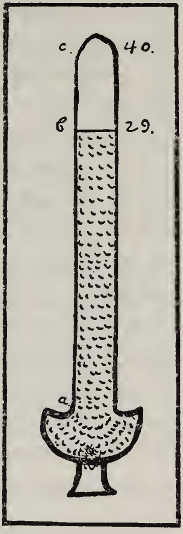


3. Weight or tendency to the Center of the Terraqueous Globe, of this it must have some small proportion, else the Upper region at least would be diffused [and] lost in the vast Æther, which lies between us and the other planets; or else the steams of the Atmosphere would hardly be held up by the reflecting sun beams; which also could not well return to their fountain, the Sun, unless chrushed up through the Air, (as cork is out of water) till they come to the Surface thereof and into the Æther where they shall meat with no resistance, and thus much of absolute affections of Air.

2. Respective are such as are ascribed to it as mingled with the Terraqueous Steame of the Atmosphere. This mixture (as before Shewn) is by the reflecting beams of the Sun carrying [up] somthing of what they strick upon; (as a boyes ball licks up Moisture or dust according to the place it falls upon) now these particles carryed up are minute bodyes keeping the Qualities of their originals. And from these it is that the 2 lower regions of the Air are denominated not only of the first Qualities,

Hot, Dry, Cold, or Moist; but have ascribed 2 notable attributes to them now to be Spoaken of Greater weight and aptness for breathing.

1. Greater weight, than that which is natural and absolute (before mentioned) This is both proved, and measured by the [Torricellian] Experiment to be Equiponderant in a Cilinder of Glass. (say of an Inch or half inch Diamiter) (or any Dimension) [to] the like Cilinder of Quicksilver ([or] Mercury, ☿) 29 Inches long; and of Water 32 foot; thus suppose a hollow Cilender of Glass (say of $\frac{1}{2}$ Inch diamiter and 40 Inches long) close at the one End (c.) and open at the other, fill it with Mercury (☿) and Stop it at the open end with your finger then invert the pipe that the close end (c.) be upwards, [Drown] your finger, and the open End in mercury (☿) contained in an open glass or Wooden vessel (a.) remove your finger and the (☿) in pipe that was before full up to (c.) or 40 Inches from the Stagnant (☿) in the vessel (a.) will presently fall down and hang at (b) 29 Inches from the surface (a.) The reason is (say they) because a pillar of the Atmosphere of the Same diamiter with the (☿) reatching from the top thereof to the Surface of the vessled (☿) in (a.) is Equipoise to the little pillar of (☿) 29 Inches (more or less) which is Sustained in the Glass pipe; and because the Close End at the top (c.) bears off the pressure of the Atmosphere from the (☿) in the pipe and it falls [without] impediment on the ☿ in the vessel; therefore it must press, or Keep up so much mercury in the pipe as will Equipoise the like pillar through out the whole atmosphere; this weight of the Atmospher varyes in Several times, and places. Therefore the Cilinder of mercury in the pipe is shorter on the top of an high mountain than in the valley; because the like Cilinder of [24] the Atmosphere is longer in the whole perpendicular height, of the Mountain, and therefore must weigh more, and have more mercury in the pipe to counterpoise it. Dr. Power (Page 104.)[1] notes that [Pascalius] in a mountain of 500 Perch high found the Difference 3 Inches whence he Sugests that by the rule of proportion we may find out the height of the Atmosphere. thus;



Height in the tube 3 Inches	Height of the hill 500 perches	Height in the Tube 29 Inches	Height of the atmosphere 4833 perches	i.e. 15½ miles.

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[1] Morton's reference is to Henry Power's *Experimental Philosophy* (London, 1664), a book which he refers to again in Chapter 31. To Power (1623–1668), Morton probably

It Varies also in the same place so [as] the Atmosphere presses upon the mercury in the Cilinder more, or less in the compas of about 6 Inches, according as the Steams are more or less assending or discending in the Air. And thus are made Barometers or ☿ Weather Glasses now of common Use.

2. Aptness, yea necessity for breathing is ascribed to the Atmosphere, and its colder parts for pure air is unapt for respiration (as is before noted). This is a perpetual Ambient Ingredient [into] our bodyes, and is always [mixing] with our animall Spirits, not only (though cheifly) by breathing; but permeating the pores of the whole body; and from hence arises the Distinction, of wholsom, and unwholsome, Sweet, and corrupted Air; for if it be Impregnated with benign [and] balsamick particles, it Cherrishes, maintains, and restores health. But (on the other hand) if the Steams are fœted, and poysonous, or otherwise Maligne, they distroy the Health, and Endainger the life. Hence fires in the streats of a Citty, Shooting of Great Guns, ringing of bels are accounted profitable in the time of pestilence; as also the natural helps of frost, and wind, Rain, etc: because these in some measure beat down, and dissipate those Miasmas or corrupted Venemous steams that hover in the Air. Hence our care is (or should be) to mind well the place of our habitation, or Settlement that the Air thereof be Sutable to our bodyes by its agreable steames; Hence also tis that some persons in Cronical distempers are sent for their health to their native air, that is to the steames that formerly agreed with them.

[Respective attributes are greater weight,
Usefull for Respiration; when tis right.]

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owed more than appears from these references; see, for a description of the book, Thomas Cowles, "Dr. Henry Power, Disciple of Sir Thomas Browne," *Isis*, XX. 344–366.

Chapter 9

Of Water

WATER is defin'd (by the Antients) an Element most cold, and humid, (or Moist) Air (by them) was Said to be most Humid, and yet (say they) water [humoctates] ([or] moistens) more than Air because of its more crass parts whereby it better adheres to the thing to be moistened. Its natural motion is downwards. Its place between the lower surface of the Air, and the Upper of the Earth, which it would all naturally cover, but that for the Use of Animals which need Air for their lives, the Earth in some places is made permanent; as Sustayned by Rocks, and So Emergent into the Air; and the water in other places is reduced into hollows, and Channels fitted to receive it.

N.B. Hence Seams to be a confusion of Humidity, and fluidity which indeed are distinct Qualityes; or at least a Humid is a fluid with an addition of adhering clammy parts, and then we may say Air is most fluid and water most humid, but that will not admit humid to be a first Quality nor will Aristotles combination of the 4 first Qualities Clinck well in finding out the true number of Elements, we may therefore conceive water to be moist, and cold, and leave Air to be most fluid.

But leaving these conjectures of the antients we shall count the attributes of water primary 3. Quantity, Fluidity, and Gravity; and other Secondaryes that arise from them.[1]

1. Quantity or Extension of Water is either Superficial or bulcke.

1. Superficial which is Especially taken notice of in the Sea; the Proportion of which to dry land is observed by Geographers, and the measure is taken of it by Mariners with a Logline [and] a Minute Glass, (the Logline is a small Whipe cord of divers fathoms long haveing at each fathoms end a knot, and [small] bitt of Cloath or rag of Several collours; one End is fastened to a peice of board, 18 Inches long, and 6 broad; the other end with all the length is round a rundle that runs round a Spill:) Now the Wood or Log being Cast out at Stern is Supposed to keep its place in the water whille the Shipe passing on draws of[f] the line from the rundle; How much goes off whille the Minute Glass runs is observed; this multi-

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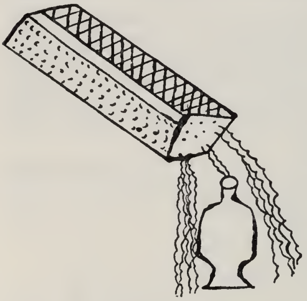
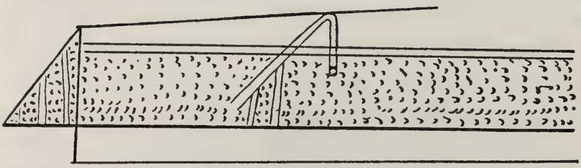
[1] Morton's remarks on water form the most interesting and most "modern" section of his book. His superiority to Legrand, for instance, is marked, and his very considerable power of combining his theory with practicalities, especially evident.

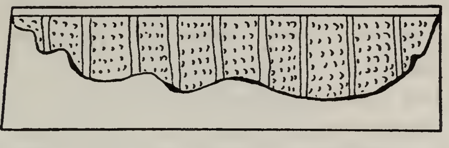
plied gives the Number of fathoms in an hour or watch (which is 4 hours) when they Usually heave the log (as they Express it) that is repeat the trials of what course they run; by this with the observation of Lon-[25]gitudes, and Latitudes they discribe the surface or compass of the Sea upon their sea Carts plats, maps, and Globes, as we have it

2. Bulkie as the 3 dimensions; this is Judged of by the Dimensions of the contayners, which we call fluid measures, as a Pint, Quart, [etc:] or by the Weight [of the bodies] contayned in the measures So a Pint is one [lb], a Quart 2 [lb], etc.; or Dimension and weight Compared; So a cubical foot of fresh Water is=to 72 [lb:] Salt watter=[lb:] 73½. to Know the Quantity of stagnant or Pool-Water is therefore easy Enough; but the Quantity of running water is to be measured by Velocity instead of length in a determinate, and known breadth, and depth: this done by an Instrument cal'd a Regulator (that is a long trough shuch as are at overshot mills,) and a Pendulum of 3 foot 7 Inches (or 43 Inches) which Vibrates a true 2d of time (that is a $\frac{1}{60}$ of a minute) Now if you put water to run through the regulator (which shews the breadth, and depth) and put a Chip or Cork to float on the water, and at the Same time move your pendulum, you thereby get the length in so many 2ds of time: If you then also receive the water [at] the falling end into Vessels either the Whole Stream, or any [one] part of the Stream Equally divided into what number of parts you please (say 3 [as] in the Diagram whereof one is saved in the Vessel) now by the measure of these receiving Vessels, in such a time (say [10] 2ds) compared with the breadth, and depth of water in the regulator it is easy to compute what [quantity of] water passeth in a minute, hour, Day etc: In such a regulator so far fill'd, and in such a declivity. By this also you may Judge of the Quantity that passes in a large river by comparing the Dimensions of this Small Regulator to those Dimensions of a Greater set up in a River like one or more door frames through which all the Water [of] the river must pass. Now the Velocityes of Each of those frames being taken by the Pendulum and the same Velocityes being examined by the small regulator you may Easily by





Computation know what is in the whole river by the proportion it bears to what is in the little regulator. If the bottome of the river be uneven and the Velocities of the sides, and middle be different; yet the computation will not be much more difficult. This will be of great Use in all manner of Aqueducts; for hereby you will know what Quantity of water every Channel with every degre of Declivity (and velocity by consequence) will carry.



Surface by Logg and minute glass is known
Bulck by a trough, [and] pendulum is shown.

2. Fluidness or aptness to spread, and insinuate itself among the smaller parts of another body apt to receive it. Now many bodyes are not apt to receive it, but do oppose it. And about this disinclination various arts are Exercised, partly to make advantage of it, partly to Subdue it. The Bodyes that refuse a Mixture with water are all fatty Substances, as Tallow, Oyle, Grease, etc:; and all Cerasious, and Recinous bodyes; as bees-wax, Pitch, Tar, etc: the advantage made of their keeping out water is their being applyed to Ships and boates in their hulls, and Tackles; also Oyling, Waxing, [and] Liquoring of leather; as in boots, Shoes, etc: The Subduing of this reluctance (that by water these, and the like things may be servisable to us) is gotten by divers usefull arts which have been found out whereby these things so averse to water in themselves may yet by Somthing of a middle nature become Sociable therewith: This Middle thing is Salt which is a mean between Earth, and water partaking Somthing of the nature of both. The Earthy parts of it will mingle with Earth, as being congeniall with it; and the Watry parts of it will disolve in water, and So associate themselves thereto and yet are not those Earthy, and Watry parts So seperated but Still they have an aptitude, and Inclination to conjoyn and [so] fasten all togather this is the Ground of many domestick opperations; as making Soape, Washing, Brewing, Baking, etc [26]

1. Making Soape wherein Water and Oyle, or Tallow concorporate by the help of Potashes, and the Salt of lime. Potashes is an Alcaly or salt of Vegitables made of the Lee of Wood-ashes and has in it a Good Quantity of Sulphur, or fatty Substance; therefore care is taken in the making thereof that the Infused brushwood when it is to be burnt do not flame least the Sulphur be consumed, and hence it is that it smeals like Gunpowder in which we know Sulphur has a considerable interest; The Salt of lime gives fixation to the potash which otherwise would be too Volatile

for this purpose when the vehement heat of fire should come thereto.

2. Washing is a Using this Soape as a mean whereby water can mingle with the Greasy foulness of cloaths; and then by its weight falls of[f] and carryes the greasy filth with it. Yea Some Sharp Salts free from Sulphurious parts do peirce and work upon Gums, and Resinous bodyes; as Sharp Viniger Juice of Limons, and Spirits of Vitriall; and some Earthy parts, (as [in] fullers earth) do mingle with clammy bodyes, and get them off. But all these opperations do need agitation by fire handy labour or both togather. Firey particles do enter and open bodyes and So give passage for water to follow them. Beating [or] rubing also do thrust in parts of water by Violence therefore both are commonly Used in Washing.

3. Brewing proceeds on the same Ground for the fire opens or melts the oyle of Malt, and mingles the body of water with it. Then the bitter and stippicall salt, and Sulphur of Hops binds them both togather till there begins a Quarrel between the Grosser and unapt parts of Sulphur, and the water with which they cannot mix, and then in the fermentation they are cast of[f] in the barm.

In Ale the forementioned fermentation is Sooner, because there only the heat of the water hath attempted their Union which is not So firm as by the Stiptick hops In the mean while the tenuious, and more Volatile parts do remain concorporated with the Water, being fine enough continually to permeate all its pores, and the Vessel being well stoped Suffers them not to Evaporate and fly away: Therfore they continue their motion Every way in the body of the Liquor this is cal'd the life and Spirit of the beer. But if in the perpetuall Agitation they meat with any Groser parts not before cast off; some of them [they] attenuate [and joyn] to their own bodyes; others (that are inseperable) they precipitate to the bottome where they attain the name of Grounds.

N.B. Tis therefore profitable not to take off too much of the barm, nor to Suffer it too long to work that way.

4. Elixation or boylling of meat is of the same nature for the Water helped by the fire gets in among the parts rarifying some, and Seperating others which are of insuperable [crudity].

5. Making of bread where[in] water by stirring and kneading gets in among the flower, and causes them to adhere, (not by Clamyness communicated; for that the Water has not; but) by filling all Cavyties, and So rendring the parts polite one to another whereby they stick togather as polished [marbles do]; hereby the Volatile parts or Spirits of the flower are retayned even when they are put into motion by the heat of the Oven; they therefore rayes and swell the Mass, and the parts of water rarifyed

do mingle with these Spirits, and help to fill the caverns which the raysing hath made, and their Embod[y]ing with the bread do render it more apt for our nourishment, and thus for its fluidness.

Water 'mongst other parts itself doth spread,
Hence fit for washing, Making Soape, beer, bread

[3.] Gravity of water is whereby it hath a tendency downward and gives a pressure to what is under it; this is either absolute, or comparitive.

1. Absolute; and so one Pint is [ac]counted [lb:] 1. a Quart [lb:] 2. A Gallon [lb:] 8. a Cubical square foot of fresh Water [lb:] 62; of Salt [water] 63½ a tun of fresh water 20 C: Lees or Lixiviums exceed water according to the solution of Salt in them, because salts are hea[v]yer than water; from this (and Fluidity as a notable secondary affection) arises the motion which is every way one way or reciprocal.

1. Every way call'd flowing, when any parts of water are raised higher than any thing besides it that should contayn it; then because of its [fluor] it contaynes not itself, and because of its weight it fals and runs about any way that it can til its Surface be reduced to Equality. Hence [where] rivers by accession of waters are raised above the banck they overflow the meadows.

2. One way, and this is either natural or forced.

1. Natural by Each parts proper Gravity, as in rivers and fountains whose [27] lower water falling away (having no impediment) do leave space for higher waters to fall after them. This is augmented or decreased by Velocity according to the declivity of the bottome (cal'd the fall) and the rectitude or curvity of the Channel. These in Natural Currents are accidentally varied according to the hardness or softness of the Ground where it runs; hence deep pooles being slow; and Shallow streams swift, [are] So convenient for the breed, and nourishment of fish. But in artificial derivations; whither draynes, and conduits where the design is to draw as much water as posible the Channel shoul[d] be straite (as may be) Shallow, and of Equal current. This preserves full Velocity, and Quantity, charges not the bancks, and Saves needless length, add to this to make water move forwards, at least one foot below the level of an Instrument must be allowed to every mile, in respect of the roundness of the Earth, and this being [d]educted you may account the rest Effectual fall. But of these things more elsewhere.

2. Violent, by pressure of other water, or other body.[1]

1. Of other Water hereby it ascends contrary to the nature of its

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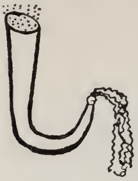
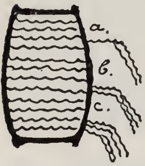
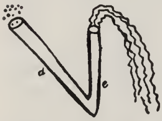
[1] Morton's hydrodynamics reflect vaguely the investigations of Torricelli. See A. Wolf, *A History of Science, Technology, and Philosophy in the Sixteenth and Seventeenth Centuries*, pp. 222–223.

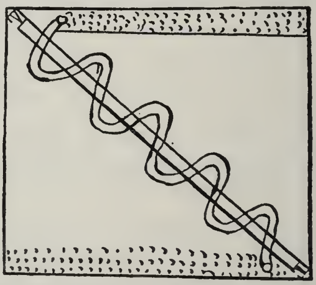
Gravity, and therefore its ascent must be reckoned but as a passive power. This is the motion out through an hole in the side, bottome or top of vessel or in the [Smaller] End of a pipe turn'd upwards (as in the Diagram) whereby are made those springers in artificial fountains. here the rule is; the Swiftness strength, and Quantity is according to the depth, and weight. Thus if a Hogs head be set on its end, and 3 holes of equal bore be mad[e] in the side [as] at (a.b.c.) more liquor runs out at (b.) than at (a.) in the same time, and more at (c.) than at (b.). In a Ciphon inverted (or crooked pipe) water will ascend as much as it descends, to bring its surface equall, where is no other pressure than the water in (d.) to poyse up the water in (e.) both being within the pipe; but if the conical figure of the Discender be inverted (as in the Upper figure) then the pressure is augmented and the water will mount out [of] the smaler end of the pipe according to the height of water in the Larger Cone; but then that never rises above the Surface of the pressing water, and parhaps it is allwayes somewhat lower.







2. Of Other bodyes, or powers, as compressed Air, or pounsells which may have Weight as those at the Water-house at London-bridge; or strength as by the Staff of a Water Engine, or springer; then will it fly much higher than the common surface, as we may see in the Engines made for Quenching of fire, and other devises by Water Wheeles or Wind Wheeles to force up water for the Use of Cityes. But all those things are Chargeable, and lyable to breach and wearing; therefore conduits of water (where they may be had) are more Eligable; for nature directed to serve our occasion will rather comply than yeald to any force. But of all such Engines the Water Screw[1] appears most admirable, in which the water seams to ascend by discending (and So it would be referred to the former motion of proper Gravity) but indeed it is impossible for water to ascend above its primary surface without a force; It is done therefore by a mixture of



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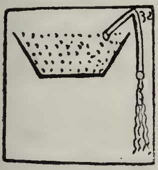
[1] The diagram of the Archimedean screw for raising water probably comes from a famous description of the water-works at Augsburg in Germany, printed originally in Girolamo Cardan, *De Subtilitate* (Nuremberg, 1550). See Wolf, *History of Science*, pp. 524–534, where is also described and illustrated the water engine at London Bridge, mentioned by Morton just above.

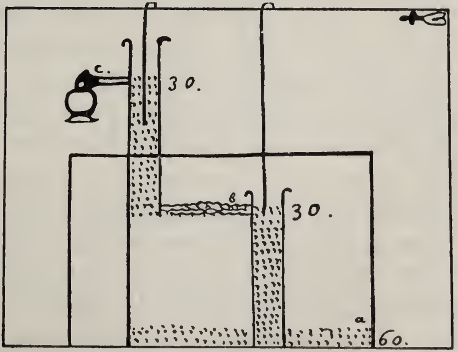
force, and Inclination but force has the Cheifest hand therein; for the turning of the Engine Screws up the surface of the water and then the body of it follows so that in every round it lifts up the water so much as the one round is above the other, and whereas the water in the Screw is alwayes running downwards that is only to prevent its being lifted up by any part of the fixed pipe, but that which is directly under it. This sort of lifting may be illustrated by a little water standing on a trencher one side of which being a little raysed up puts the water a running to the other side and so to run off the table; yet if before it run of[f] you raise the other lower side a little, and at the same time raise ano-[28]ther by-side of the trencher, you'l find the water will not run over, but turn aside as the declivity is varyed. Now this lifting up in the Screw is continued wherein the Motion of the parts of the Pipe upwards dos anticipate the motion of the Water downwards, and so snatch it with them ere it can remove out of the Way. They moving first and faster than the Water, must needs therefore get Ground thereof. This is a thing of very curious consideration, and requires some skill in Mathematical Mechanicks to apprehend it. And thus much of the motion of water one way, and every way now of reciprocal.

3. Reciprocal motion of water is a proper affection of the sea (wh[i]ther we shall referr it) only note it here as a species of waters motion. And this of absolute gravity.

2. Respective Gravity of Water is the same [compared] with
the Atmosphere.
other Liquors.
Solid bodyes.

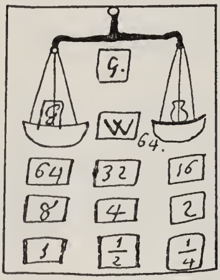
1. The Counterpoyse of Water to the Atmosphere is 32 foot more or less (i.e.) a pillar of the Atmosphere from top to bottom will press water into a pipe 32 foot high; therefore we cannot make water [by Succion] in a Cyphon (or pump) to rise higher than the 32 foot perpendicular for beyond that it will leave a vacuum (or only Ether) rather than rise (as in the Torricellian experiment before noted.) And hence it is if the Upper surface of water in Wells lye





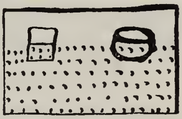
deeper than 32 foot men are forced to make double Pumps; as, Suppose the other surface of the Water at (a.) be 60 foot under Ground, you'll need two pumps, one to draw it 30 foot from the surface (a.) to the Cystern (b.) and in that Cystern to plant another pump to draw it [up] 30 foot more to the bucket (c.) for your Use.

2. The Counterpoyse of Water to other Liquors; as Milk, Beer, Wine, Brine, Mineral waters, etc: this is according to the Mixtures or solutions of other bodyes in the liquors which are more heavy than waters, these must be Earthy or Saline parts; for Spirituous, and Sulphurious are lighter than water; the discovery of this may be of Great Use, and delightfull curiosity, and this is done by the say-Glass (heretofore accounted a Great mystery, but) Now of common Use with soap boylers, and potash-men, to know the strength of their lees; Take the fabrick of it thus: Get a small Scale, and a Glass-bottle of any Quantity (say $\frac{1}{2}$ a Pint or thereabout) to counterpoyse it in the scale by a thin plate of lead (say as thick as a Crown peice) whereon set the Letter (G.) signifying that this is the weight of the Empty Glass. Then fill the Glass with the Clearest fountain water and put [it] in one scale, and the Glass weight in the other; also add to this weight (G.) another weight which with that of (G.) will be Equipoyse to the full Glass and therefore this [other] added weight will be Equall to the Water, and let it be marked on the [one] side (W.) and on the other side (64). This last weight (W.) is to be divided thus. Put it into one scale, and in the other its equal weight of Sand; having Done this remove the (W.) out of the scale and put in its place $\frac{1}{2}$ the sand which you may do by removing a little of it, [on] the poynt of your knife from scale to scale till they be both even then cast away the sand out of on[e] scale, and fitt a lead equall to the remaining half, and mark this lead with (32.) in like manner divide this again and again untill you have leads marked (64, 32, 16, 8, 4, 2, 1, $\frac{1}{2}$,) this one is called a Carrick or $\frac{1}{64}$ of the water weight things being thus [prepared] you may [now] fill your glass with any liquor, and see by the scale how many [Carricks] it is heavyer or lighter than water. [29] [And so you will find spirituous and oyly liquors lighter than water] Whereas Saline, and Earthy will be a Great many heavyer. I have seen a Clear lee of lime to weigh about 30 [Carricks] more than water; for it seams to be the heaviest of all l[i]xiviums.



3. The Counterpoyse of water to other solid bodyes, such as Wood, Metall, etc: hence arises (as a Secondary affection) Navigableness or an

aptness to bear up a body on its Surface, and also (by reason of its fluidity) a yeilding to its motion forwards, by any easy Movement (supposing there be sufficient depth) the reason of bearing up [is] the Equipoyse of so much water removed out of its place by the weight of the body lay'd thereon; as, Supose a Cubical square foot of water weigh 62 [lb:] then a Cubical foot of wood weighing 31 [lb:] will half [Immerse] or sink, and half [Emmerge] or swim above water, because its weight can remove but $\frac{1}{2}$ a foot of water out of its place; hence it follows that salt water bears up better than fresh, because heavyer (as is before noted) and metals (though heavyer than any water yet) being shaped hallow (as a dish) may thereby be apt to remove more water than their own weight, and So Swim as well as Wood.



And thus much for the General affections of water Quantity, Fluidity, Gravity.

The principle parts of water are sea and fountaines.

1. Sea (or Ocian) [is] the collection of waters, Genesis. 1. 10. it is an Integrall whole, and therefore has not Species, but integrant parts, which have their accidental denominations from their Quantity or adjoyning lands, as Main, Ocean, Creek, bay, harbour, [etc:] English sea, Irish sea, etc: of which mor fully Geographers its Cheif affections are saltness, and reciprocation.

1. Saltness concerning the Cause of which have been diverse oppinions.[1]

1. Some have thought it concreated with the sea; but then surely it could not so easily be seperated from the water as we see it may [be] by distillation, and other evaporations; as by the sun whereby bay salt, or by fire whereby other common salt is made

2. Others have thought it caus'd by the sunbeams drawing off the Sweeter parts and adusting the rest, but then the sea would be salter in the summer than in the Winter which we find not; and besides there would be no sweat water in [hotter] countryes.

3. The most likely cause of it is the solution of Salt Peter, or other salts of the Earth which it continually receives partly by washing submarine peter-rocks, and partly as the common sink after rain receiving all the

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[1] Speculation on why the sea is salt is of course an ancient pastime, and may be observed as far back as the *Meteorologica*. But Morton's comments appear to be related to contemporary discussion. He could have obtained his information from a review of some of Boyle's tracts which appeared in the *Philosophical Transactions*, No. 97 (October 6, 1673). Some phrases, however, suggest that he knew a letter by Martin Lister which appeared in the same periodical, No. 156 (Feb. 20, 1683/4), in which case the *Compendium* must have been added to later than 1680. Or Morton may have known Boyle's *Tracts Consisting of Observations about the Saltness of the Sea* (London, 1674).

filth of the Earths Surface wherein there is abundance of salt. Nor nead we fear the sea should hereby [at last] exceed in saltness, because as it dayly receives, so it dayly imparts its saltness when it insinuates itself into the caverns of the Earth to become the Matter of fountains; Where it percolates (or straynes) well, the salt is lodged in the Earth. The more fixed parts to be subservient to Mineralls, the more Volatile to arise and become the salt of Vegitables; but where it has free passage, and straynes not, it makes salt fountains such as we find at Nantwitch[1] and the places thereabouts, there can be therefore no stagnancy of salt in the sea, seing it has its circulations through the Veigns of the Earth.

2. Reciprocation or Ebing, and flowing whose End, and Efficient.

1. End that it may better serve Navigation, and (say the Antients) least the sea should putrify [but] how is it then that the Greatest part of the ocean [having] no tides dont stink us out of the world.

2. Efficient Was antiently Guessed to be the moon whose motion the sea was said magnetically to follow, other[s] ascribe it to the pressure of the moons rayes on some part of the sea and thereby forcing it to rise in others. This Regency of the moon and relation to the sea was Supposed, because the spring, and Neap-tides keep time with the full and new moon, and so they fall into the fallacy of cause for not cause. But to say the truth the antients ware as much at a loss in this as in any part of Phylosophy; yea there is a traditionall story of Aristotle to be so much trubled at his Ignorance in this matter, that he threw himself headlong into the river Euripus, and drowned himself; Saying, (since I cannot [take] thee, take thou me) After he had stood poring long on this p[h]aynominon, (of the Ebbing, and flowing) and could obtain no Satisfactory account thereof in his thoughts. but since the Copernican scheme hath [obtained] some credit in the world, there is an easy, and natural way thereby to solve these appearances, which we shall breifly explain The P[h]aynominon of tides are either common, and natural; Extraordinary, and Accidental.[2]

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[1] A description of the salt springs and of salt-making at Nantwich in Cheshire appeared in the *Philosophical Transactions*, No. 53 (November 15, 1669).

[2] The discussion of tides makes perhaps the most extended use of a single source which Morton allowed himself. Although he says that "these times are taken out of Galleleus," it is clear, as Mr. Morison has said, that Morton has carefully studied John Wallis's essay "exhibiting his Hypothesis about the Flux and Reflux of the Sea," which appeared in the *Philosophical Transactions*, No. 16 (August 6, 1666). There Wallis summarized Galileo's theories, agreed with them in general, and then suggested a theory to account for phenomena left unexplained by his predecessor. Nearly one third of this chapter will be found to derive from Wallis's essay, whence come also the figure on p. 65 and the first figure on p. 67. Furthermore, as the text indicates, Morton made a synopsis of Wallis's article, with further diagrams, which was inserted as an appendix to the *Compendium*. It

1. Natural are the reciprocations in the 3 Periods Diurnal, Monthly, and Anuall.

1. Diurnal twice in 24 houres, that is Ebbing 6, and flowing 6, or about ½ an hour more in every tide. In this are 3 varieties, Rise without currunt, currunt without rise mixt of both currunt and rise

2. Monthly a Gradual increase and decrease in height and greatness of the tides every fortnight, [**30**] [called Spring and Neap Tides.]

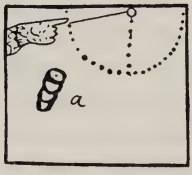
3. Annual Augmentation of these springs and neaps about the Solsticial points or soon after the longest and shortest dayes, the Springs are highest, and the neaps lowest and about the Æquinox when the dayes and nights are Equal Spring[s] and neap[s] are of less Quantity.

N.B. These times are taken out of Galleleus But Dr. Wallis observes and assigns other times and reasons after another manner (or Sort) concerning this matter as may be seen in the Appendix after these Physicks.

2. Accidental are variations from the Common periods by the Scituation and figures of Channels, depths of water Stormy winds, Nearness of vast Oceans, which give either movement or impediment, and hence arises Effects, some more constant as the mentioned currunt, Rise of water, some altogather uncertain, as Extraordinary floods, [and] Doubling tides.

Tides natural are in a Day, Month, year;
Tides accidental variously appear

Now to find out the Cause of all these from the copernican Hypothysis Comparison is made [of] the sea to [the] Water that may be contained in a Vessell; for Channels, and lower or hallow parts of the Earth are but Greater Vessels capable of Greater Quantityes of Water The Reciprocations they compare to the Greater Swayes of a Pendulum wherein some outward cause at the first (say a mans hand) brings the bullet to its height, but afterwards its fall is back again, and continued to swing by its own weight; in like manner dos water being forcibly raised up by one side of a Vessel, through its own weight, and fluidity fall back again, and So continues to sway from side to side. Now the Motion of the Vessell may Cause the Water to Ascend by one side, by altering either its Site or Velocity.



1. By Altering the site of the Vessel (as in the figure a.) inclining it to

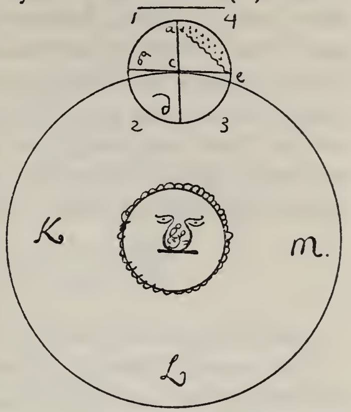
is to be found at the end of the Rogers MS., but it was evidently an integral part of the original, since it is mentioned twice in all the American transcriptions. Morton's skill as a teacher is well exemplified in his use of Wallis; he condenses, simplifies, and everywhere makes the material more concrete by the use of homely illustration.

one, or other side, and then the parts of the bottom must be altered in their Distance from the Center of the Earth, (or of Gravity) which presently causes the fluid water to flow toward the lower part: But the bottom of the sea can never have its distance thus altered, and therefore this way will not serve our turn.

2. By altering the Velocity of the Vessell[s] motion from rest (or slowness) into motion (or swiftness,) and on the Contrary from Swiftness into slowness; either of these will cause the riseing of the Water, at one, or the other end of the motion, as, Suppose a boat carryes a long trough of water [placed] according to the length of the boat, and the trough be fastened thereto, If the boat be thrust off from the shoar where it rested after the prow, the trough will immediately have the same motion, because fastened, and Solid; but the Water being lo[o]se and fluid will not presently take the Motion, but linger a little behind in the state of rest wherein it was before; therefore the trough going on from under it (as boys strick out the neithe[r]most of 2 Groats laid on the top of their thumb,) must leave water to heap and [so] rise in the stern by shuffling the former, and hinder water togather; but here it will not rest; for when it is risen as high as it may towards [the stern by] that motion of the trough it falls away again forwards, towards the prow by its own Gravity and So by degrees comes to a forward motion equal to that of the boat. and then keeps on in the same velosity with it. But in Case the boats course be retarded, or stop't, the Water dos not presently retard, or stop with it; because of the lo[o]seness and fluidity before noted therefore the water continuing the same velocity for a While, it must shuffle parts togather and rise at the prow as it did before at the stern.

Now in the Copernican Scheme the Earth trolling itself roun[d] its own Axis (as a bowle) in the Diurnall revolution, and withall round the Great orb ascribed to the sun by Ptolomie (as it ware the length of the Green) in the Annuall revolution, the Center of the Earth runing in the line of the Great orb; therefore the superficiall parts of the Earth must needs have an [unequall] Velocity; for any one part (Say the meditarenian) must somtimes move forwards (from west to East) with a double Velocity namly that of the Diurnal revolution Superadded to that of the Annuall, as appears by the Diagram. Suppose the great Circle [be] the Grand orb, or Eccliptick (in whose Center is the sun) the less Circle is the body of the Earth (whose Center (c.) moves in the Eccliptick onwards from the place (c.) [to] K.L.M. etc: mean whille turns (a) round by (b.d.e. etc:) 365 times,) Suppose also the Place between (a. and e.) is the meditarenian sea; [**31**] Now (a.) the Superficial part of the Earth between (4. and 1.)

hath its motion concurrunt, or the same way with the Center (c.) therefore while it passes in that distance the Superficial (or Diurnal) Motion must be added to the Central (or Annual) while (a.) is moving between the points (1. and 2.) it neither adds nor diminishes, because it neither goes forward with, nor backwards against the annual motion, but only downwards from (1. to 2.) as on the other side it goes upwards from (3 to 4) therefore while it is passing these two distances the Motion of the Superficial point (a.) is only the same with the Center (c.) in the Anual Course, but whille (a.) moves between 2 and 3 it goes backward, [and] contrary to the Annuall motion; therefore you must Substract from the Annual so much as the diurnall motion shall in that while be. Now you must note that the Velocity of the Annual motion is 3 times [Greater than] that of the Diurnal; If therefore you call the Diurnal motion[s] Velocity 1 Degree; then the Velocity of (c.) is 3 degrees to this add one and that is 4, or from this Substract one, and it is 2 Degrees; so then the point (a.) Or the meditarenian (a, e,) moves 4 Degrees of Velocity between the Points (4, and 1,) 3 Degrees between, (1, and 2,) 2 Degrees between (2, and 3) 3 Degrees again between (3. and 4) etc: From hence twill follow that the Sea of a long tract (E, and W) and near the Equator where the Superficial parts move in the Greatest Circle must have the Greatest tides because [in] them [is] the Greatest [diversity] of motion whereas Seas nearrer the Poles, and lesser Circles and Such as have but one or two degrees E. and W. Longitude, also seas [but] of Such a breadth though they have a long tract N. and S. (as the red sea) have not sensible tides at all; because the reciprocations are so frequent that the flux, and reflux from shore to shore, do interrupt and break the course of one another, it follows also that far out in the ocean can be no tides because the reflux from the shore runs not so far out, before there is occasion for a new tide at the Shore.—Moreover in long, and narrow seas, especially nearest the poles where the Circles of their motion [are] not so great the flux may be at both ends at once, for one End may be [in] swiftest motion, when the other may be in slowest because of the length of the Channell. Lastly it follows that tho tides in the sea run (East and west) yet in rivers, and bayes it may [flow] N. and S. or any other point because of the course of the rivers; So in the sea be-

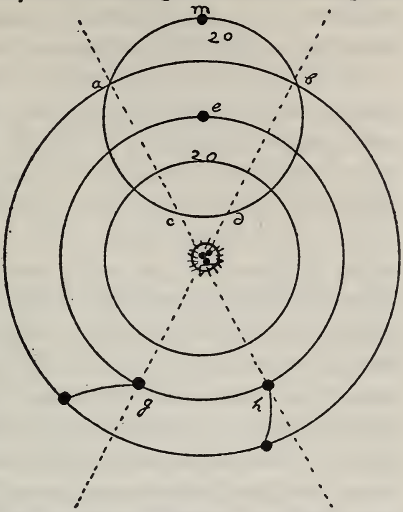


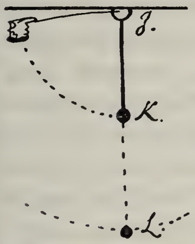
tween England, and France the tide is E. and W. But in [Southampton] river, and [in the Sea] between England and Holland it flows N. and S. and in the Thames it flows west at the same time [when] it flows East at Dover; because the rising waters of the sea rushes into the rivers and streights which way soever they lye; as for the doubling of tides, and uncertain Great overflowings, it may be from the suddain sea-storms interrupting, and precipitating the tides natural course and from Great land raines increasing the waters of the rivers

P[h]ainominon of tides hath its Solution
from Earths Swift, Slow, unequal revolution.

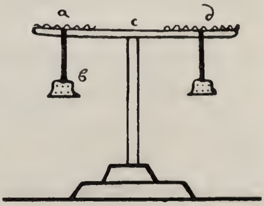
And thus much for the diurnal tides, and their Accidents.

The monthly variety of Spring and neap is solved in augmenting, and diminishing the fundimental cause in the Diurnall revolutions, for if in [divers] times of the Month its dayly revolution is accelerated, and retarded more than is before shown; then the Causes of the flux, and reflux being increased the Effects must be also increased accordingly. This alteration of the Earths revolution is by the moons motion round about it; not that the Moon has any thing particularly to do with the water but rather with the vessel which contains it retarding and accellerating motion therein according to its various positions in respect to the Earth. for (say the Copernicans) the Moon is by the law of nature oblidged to be still moving round the Earth at a Certain distance (as the New found attendants of Jupiter do dance about its body and accompany it about its revolution) so that the Earth and Moon togather make as it ware but one movable about the Grand orb, or Eccliptick; hence it comes to pass that somtimes the moon is farther from the sun, (the Center of the Eccliptick) than the Earth so far as the dis-[**32**]tance is between the Earth, and [the] Moon now the Moon keeping the same course about the Earth [yet] ridds less way onward under the Eccliptick when it is farther from the sun because it then moves in a Greater circle whose degrees contain more miles, and therefore in respect to the Eccliptick, (or Annuall revolution) it may be said to be more slow, Now the Earth being nearrer might therefore outrun it but that it cant leave it behind, because of the Certain distance (before Mentioned) which must be kept between them; it therefore follows that the Earth must [then] linger, and slack its course when the moon laggs behind, that it may still have the Moons company, and (on the other hand) when the moon is nearer the Sun it Gets onwards more degrees in less time, because of the comparitive littleness of the Circle, and therefore may be said to move faster than the Earth which yet it cant forsake and by consequence must [pull] it on faster by the unchangeableness of the [Said determinate] distance; as, in the Diagram, Suppose (e.) the Earth be moving its own course in the middle circle, (i.e. the Grand orb,) and (M.) the Moon be moving in its course round the Earth Suppose also the 2 Pricked lines make an angle of 20 Degrees in the Center of the sun you see this twenty Degrees is but a little way in the Inward circle at (c.d.) When the Moon shall come thither between the Earth and the Sun; but tis a Much Greater way to make up the 20 Degrees in a Greater Circle; as at (a.b.) about the place (m.) when the Earth is between the sun, and the Moon This is also illustrated by the weight of a Pendulum string; for if it be shortned the bullet move[s] Quiker than when let down to a Greater length; as suppose an hook struck in a Ceelling, and over it goes the string of a pendulum if you let it down no farthar than from I to K. the Vibration[s] will be Quick, but if you let the bullet slip down so far as L. it will alter its pace and turn slower Now if there ware 2 bullets hung by one string (as in the former Diagram) where the Sun is as the hook (or Center of the motions) the Upper bullet represents the Earth the lower the moon, that nearer to the Center (the Earth) would move from (g. to h) but the remoter (the Moon) would hang back, and not be able to keep pace with the other, and though the nearer [bullet] (representing the Earth) be Greater, and therefore must overrule the motion of the less (representing the Moon) yet the less will some way retard the Greaters motion.



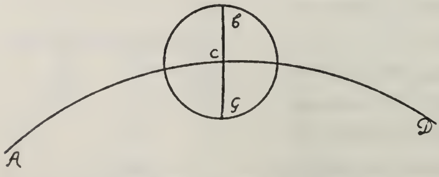


They also Illustrate it by two poises that hang on the fly of a large publique Clock; for if but one of them be removed farther off from the Center; as Suppose the weight (b.) be removed out of the notch (a.) which is farthar from the Center (c.) than the Notch (d.) then the motion of the whole fly and by consequence of both the



Weights appendents thereon will be retarded, (as on the Contrary) accellerated if either of them be removed nearer; and thus much of the monthly periods, or of the Springs and neaps.

As for the 3d Variety which is annual, or the higher than ordinary springs, which (sais Galleleus) [are] about the solsticial points (or shortest and Longest Dayes) but Dr Wallis Says otherwise, and therefore gives other solution thereof as may be [seen] in the Abstract out of him, and is added as an Appendix to these physicks. But according to Galleleus they referr it to the Inclination of Axes; this is the hardest to be understood unless by them that are well versed in the Globes, and the doctrine of Sphærical triangles, and of planispharies else tis hard to make a diagram intelligible; however I shall hint something of it here, and leave it to your better consideration hereafter. The Copernicans say that tho the Earth roles about with its Center in the Eccliptick; yet it still keeps its axis parrallell [**33**] to the Axis of the Universe, and not with the Axis of the Ecclitick whose poles stand besides the others $23\frac{1}{2}$ Degrees, therefore the roll of the Earth must be somtimes direct with the run of the Eccliptick; as when its Center is in or near the Solsticiall points; because then the Motion of the Earths Center is for some dayes, (as it ware) in the tropical circle whose Axis and poles are the same with [those] of the Universe, and in this state and place the revolution of the Earths Equator [is full] $\frac{1}{2}$ [above] and $\frac{1}{2}$ below the Eccliptick then the Prostapheresis (or the Addition [or] Substraction,) in respect of the monthly periods do import as much as the whole diamiter of the Earth can effect; but at all other times and most at the Equinoxes the Globe of the Earth is somwhat oblique, and move[s] sidewayes to the run of the Eccliptick [else] the Earth could not keep its axis parrallel to the Axis of the Universe; So that at the Equinoxial points (at or near G.) the Equator of the Earth, and by consequence the Course of the Earths Revolution is oblique to the Eccliptick [$23\frac{1}{2}$] Degrees and therefore the Edge of the Equator comes nearer the Eccliptick than when it stood upright by the $\frac{1}{12}$ of the whole diamiter of the Earth. And by Consequence cuts off so much of the P[r]ostaphærisis; as, supose (in the Diagram) (A.D.) be a Segment of the Eccliptick, and (C.) the Earths Center in the Solstitiall point of the Equator (and Revolution) here the whole Diamiter (B.G) Playes above and below the Eccliptick; so that the point (B.) in the revolution of the Earth Dayly comes as low as (G.). But in the next



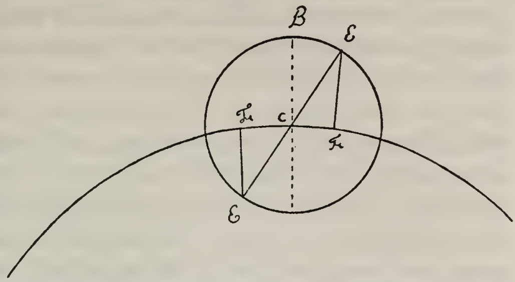


Diagram where the Earths center is supposed to be in the Equinoxial point, the Equator, (and Revolution) of the Earth standsobliquely in (E.[E.]) here the mounting above and falling below is less, So much as the line (E.F.) is shorter than the line (B.C.) or Earths Semi-diamiter: So that in the Solstaces is the Greatest P[r]ostapherisis or addition to [and] Substraction from the motion of the Earths Center in the Eccliptick, and in the Equinoxes is the least. Therefore (according to Galleleus) the Springs, and neaps, are Greatest in the solstaces, and least in the Equinoxes. The Intermediate Spaces (or times) are Varied according to the nearness, or distance of one of these cardinal points. Now all this that is said of the 3d Variety referrs to the seas, that [may be] under [or] near the Earths Equator, Where the Earths motion in Superficiall parts is Greatest. As for all other places their Annuall Differences of Springs, and nepes, are less Gradually [as] they approach to either pole; because the Motion[s] and their Differences are still less and less. The Summe of all this is the Dayly tides are from the Superficial parts of the Earth, being moved Swifter, and Slower than its Center [is] in the Eccliptick. The Monthly difference of tides is from the moons promoting, or hindering the motion of the Earths Center.

The Annuall difference is by the Inclination of Axes, or the Earths rolling [sidewise] in some part of the Eccliptick: Thus the Copernicans Solve it; but whether the Earths Center of Gravity some way Distant from the Center of its Magnitude do not somthing Contribute to this Unequall, and Wabling motion of the Earth may be worth our farthar Consideration. and thus much of tides and their Varieties.

[2.] The Other part of Water is fountains, or Springs, and rivers made up of many of them. Of these Consider the Causes, and the Kinds.

1. The Causes concurrunt to their production are the Sea, Rocky caverns of the Earth, Subterraneal fermentations or heats and Superficial moisture by [raynes].

1. The Only Material Cause Seams to be sea-water soaking into the Earth, which meeting with some Nitro-sulphurious minerals causeth

2. fermentations, Ebullitions, or heat[s], (Call'd Subterraneous fires) Such as are producted by cold water cast upon unslaked lime whence [Steams] do arise into

3. The Caverns of the Earth, and Clefts of the Rocks which are the Internall constituents of Mountains, Hills and all riseing Grounds; those Steam[s] condensed again by the Coldness of the Stone (in the Rock) these natural allimbecks drop down in water, and many drops make little currunts which break out where they can. Hence it is that hilly and rocky Countryes have most springs, and plain flates, have them some feet underground soaking every way into the Gravel: [34] If the Caverns, or Clefts be ample in one place, or the flacks of s[t]one lye to one way, then the Quantity of water collected is Sufficient to break out at one place in a living, Boylling, Bubling Spring. But if otherwise, and there be a Multitude of Small Crevises Seperated one from the other then will many small springs creep through a little Gravell at the bottom of the Hill under the surface of the flates beneath, and Swell them into Boggs. Therfore note the Cure of those Boggs is to cut off those Springs by opening a trench at the foot of the hill Just between the Wett, and the Dry.

4. That Raine hath some Influence on springs is manifest [by] scripture, and Experience; for they fail by Greater Droughts (1 Kings, 17. 7.) and after a Wett winter fountaynes break up plentifully in the Spring; but this not from a Supply of water, for Columella[1] affirms that no rain sinks [below] 10 foot under Ground, whereas fountains come from the Deep, as is manifest in mines; Tis therefore by making a convenient lute, or perhaps a refrigitory, for those natural Alimbecks whereby [the Steams] are kept from Evaporating and the Suns heat kept [off] from hindring their Condensation; Else the pores of the Earth being opened the [Steams] would Get away and become matter of rain; hence after long droughts springs are low, and (Rain filling the Superficial Crevises) they are recruited again.

2. The Kinds of fountains are simple, or compound.

1. Simple fountains, or fresh are those whose waters are Clean seperated from the sea-salt, and all other tinctures, [or] inquinations, this is done partly by percolation, and partly by Distillation.

1. Percolation, or Streigning through the Earth Cheifly through those Earths [that] are most proper for the purpose, as Chalk, Ashes, etc:

N.B. Tis of great concern to our health if the waters which Supply our houses be Good and wholsome, the best be Smooth, light, without

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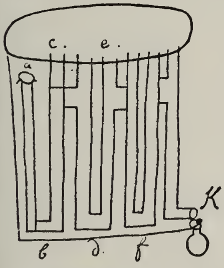
[1] Lucius Junius Moderatus Columella was the most celebrated writer on agriculture of the ancient world. A Roman, he composed, some time in the first century A.D., his *De Re Rustica* in twelve books. Morton's reference is probably to this work, but to what part of it the editor has not discovered. The *De Re Rustica*, first published at Venice in 1472, is known in many later editions.

Smell, tast, or Collour; Such will laver well with Soap, and cause your spittle dropt upon it presently to spread abroad, and not continue togather, 'twill brew manyfestly better than other water, 'twill boyle pease Soft, and beaff without blackness or redness, and feels smooth, and not harsh when you wash your hands with it.

2. Distillation, as in [that] Elevation of [steams] (before mentioned,) for thereby the salt (being heavyer, than water) abides below; and that the rather for that it needs longer fermentation, to make it volatile and apt for Elevation. Hence it is that distilling in an Alymbeck will drop fresh water from Urine, and from sea water if it hath som time in putrefaction, whereby the parts are more apt to seperate. And this is also manyfest [in] the making or gathering of salt by the Evaporating of water.

N.B. Possibly by these things well considered may be found an Expedient (hereafter) for fresh water to be had at sea, either by some precipitating matter put into the water; (as was said to be done [in] Holland) or by a convenient way of distillation (as of late is proposed here in England)[1] or perhaps [rather] by an upward percolation through matter apt to seperate, and retain the salt, the Water being before prepared by a due fermentation. An Offer unto such an Experiment may be this: Suppose a Cask filled with pipes which are stuffed with such percolating matter, and the Vessel Capable of a Good Quantity of such putrifyed Salt water as to float above the top of the first pipe tis then supposed the water will enter [by] the open End of the first pipe (a.) and then discend to (b.) then ascend to (c.) discend to (d.) ascend to (e.) discend to (f.) etc: Until it come to fall out at the cock (K.) into the bucket for Use. Now you must observe that ½ the Water in the pipe discends, and these effect little, or Nothing, because Salt in fluor will discend wherever the water can; but the other ½ that ascends must do the business. Note there may be many of these pipes contrived to stand in [one, or more] hogsheads, whereby you may have what height of Ascent will be needfull: The percolating material may be Ashes depauperated of its salt, and the pump of the ship may supply the first vessel with putrified salt water that lyes under the hold at the Keell.



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[1] One such proposal, which attracted wide attention, and in which Robert Boyle was interested, was that of Captain Robert Fitzgerald. He described his process with extreme caution—lest he reveal its secrets—in *Salt Water Sweetned* (London, 1683), a book which was in its tenth edition by 1685. However, a method of distillation of sea water was described in the *Philosophical Transactions*, No. 67 (January 16, 1670/1), fifteen years earlier.

2. Compound, or Mixt fountains are such as running through some veins that [are] mineral take a tincture or Impregnation from them such as the hot baths purging [and] salt springs etc: The Quantity of the Impregnation may be discerned by the sea Glass carricks (of which before)

N.B. In Case your ordinary pump water be a little harsh, and have somthing of mineral taint tis Good to Save it in some wooden vessels, and let it stand 2 or 3 dayes before you Use it for thereby the saline and mineral mixtures will in good measure precipitate to the bottom, and So much for water. [35]

Chapter 10

Of Earth

EARTH is an Element (by the Antients) most Dry, and cold. Most Dry is good; but cold only in a moderate degree seams to be a mistake, because that is most hard which is caused by coldness, (as is before noted.) By the Moderns the Earth is a Mass of Gross particles, of Irregular figures sticking togather, by their Quiet or absence of motion through unaptness thereunto.[1]

Its Cheif affections are Soliddity, Gravity, figure.

1. Soliddity or hardness more or less according to the Quiet of its parts yet it hath pores permeable by the finer matter of fire, and heavenly Influence.

2. Gravity is the tendency of its parts to its own proper Center, this they Call a Quality inhæring in solid Parts. Cartesians will have it to be by pressure of Cœlestial particles, which stirring every way thrust togather those Earthy parts unapt to partake of their own Motion. I should rather call it obedience to the primary law of nature whereby the Creator ordered, directed and Distributed all parts of matter (as soon as made) into their several fellowships, therein to be conserved by mutuall support; and that they might not be distracted in Seeking out their companions in the boundless Abyse, a Center was appointed for the place of meeting, and concurrance, being thus brought togather they continue so out of self love for their own conservation, and from hence arises that love of their fellows, whereby they are (as it ware) loath to part when they are once joyned to Each other in continuity, [and those continually heaped up togather in Contiguity] have also some measure of mutuall adhæsion; this we may call the harmony or Concord of the World; to which flocks of brutes, and Societyes of men do bear some proportion and analogy.

3. The Figure of the whole (togather with its water) is round, or Globular, (not regarding the little pertuberances of mountains which are as nothing in respect of the Earths magnitude;) for 3 miles perpendicular

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[1] The ancients' definition of earth comes from the *De Generatione et Corruptione*. The remainder of Morton's discussion is largely Cartesian, and should be compared with the *Principia Philosophiae*, Pt. IV. There are hints of the same ideas, too, in Boyle's writings, especially the *Essays of Effluviums* (London, 1673) and *An Essay of the Great Effects of Even Languid and Unheeded Motion* (London, 1685). Legrand (*Institutio Philosophiae*, Pt. VI, ch. x) covers the problems of magnetic and electrical attraction in very similar terms.

height (the Utmost say they of any mountain) is less then [$\frac{1}{1000}$ part] of the semidiamiter of the Earth, now this roundness appears

1. By The Elevation of the Pole 1 Degree in about 60 Miles, which could not be if the Surface of the Earth ware flat, and plain, and not round.

2. By the Earths Shaddow on the body of the Moon in an Ecclipse is round.

3. The Experriments of travel by Drake, and [others] who have Gone round about it put it [now] out of all doubt, though some of the Antient fathers ware in the dark as to this matter yea they would derive or back their fond conceits of the Earths flatness, from Scripture; as Psalm 19. 6. the Ends of the Earth. This is the same sort of misapplying of Scripture with that used by some to refell the Copernican motion of the Earth. Hence N.B. then that in Physiologicks latter ages may be better instructed.

The divisions of the Earth is into [2] Regions upper, and Inferior.

1. Upper is more Lax and open, Entred by the Suns heat, and showers, moisture, and giveing place for the roots of Vegitables. This Superficiall part being more manifestly Usefull for the Dayly support of man therefore fell more Expressly under the Curse of mans Sin which curse consists in 2 thing[s] Sterillity [of good], and fertillity of bad.

1. Sterility (or non-production) of that which is Good without much labour, and industry.

2. Fertility (or free-production) of what is comparitively Evill, as weed[s], etc: that hinder the fruits.

> Earths Surface cursed for mans sin is still
> Sterill of Good, feracious of Ill.

Now to cure those inconveniences (in some measure) is the skill of Husbandry, and Agriculture, which considers 3 things the variety of Soyles, deseases, and remidies.

1. The Variety of Soyles, Judged of partly by the Colour, partly by the Grit or small stone therein, but especially by the natural productions, and accordingly offers to it seeds, or plants Sutable.

2. The Variety of Deseases, Each Kind is subject to; whither from the Scituation from Want, or superfluity of water; from over or under tillage, etc:

3. The Several, and Sutable remidies, by fencing tilling, dressing, with agreable manure Dreyning, Gathering out stones, etc: and accordingly apply[es] labours and Endeavours.

2. The Inferior Region of the Earth is more Solid, because the weight of all above dos press the parts closer togather so that they come to the consistency of hard stone, which is either metal or magnete.

1. Metalline is the principle of mineral, or other fosciles, for some parts thereof when they are sufficiently maturated to arise or become active do steam up from the neither mass, and mingle with the Superior parts of the Earth which are passive, and in them by various mixtures make such alterations as they are severally Capable of.

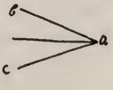
The Active parts the Chymists call salt, Sulphur, and Mercury; the passive parts are Several in diverse countryes which have in them also active parts (call'd the Peter of the Earth) this further ascends in springs to produce the Growth of Vegitables, and discends again in Winter, whereby there is a stop put to Vegitation. But if they meet and mingle with these metalline steams mentioned, they concorporate with them and contribute to metals but ascend not to serve vegitables being directed to another purpose, and hence is the superficial barrenness of all [Minerall] Grounds affording little else than worthless [heath] unless Good husbandry do amend them.

Earths Peter which to Growth of plants inclines,
Meeting Metallick steames with them combines.

2. Magnetick this is purposed to take up the Greatest part of the Earths body therefore (by many Moderns)[1] the Whole Earth is pronounced a Great magnet, and the Mag-[36]natism thereof (they think) is the [Cause] of that Great, and [notable] Effect call'd Gravity. Now the Magnet has two Eminent Qualities Attraction, and Verticity, to the Poles both which they solve by the motion, and figure of Certain Corporeal atomes which proceed from the poles of the Earth, and Wheelling about in a Virtical motion return thither again; these in the pores of the Earth of the Magnet, and of the Iron [find] passages sutable to their motion, parrallels to the Axis of the Earth or Magnet, as also [to] the length of Iron, and therefore they Whirl about continually through these bodyes; whereas all other bodyes obstruct their motion.

1. The Verticity (they say) is from their Motion causing the Channel[s] through which they pass to turn if the body be small or well poysed, and to stand right in the line they naturally incline to Goe.

2. The Attraction (they say) is from the figure of those particles which they account to be somewhat like an arrows head, or forked now the [sharp] End (a.) coming into the Iron



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[1] There is little evidence that Morton knew at first hand the work of William Gilbert of Colchester (1540–1603), whose *De Magnete* was published at London in 1600. This reference shows, however, that Morton was familiar with some of Gilbert's ideas, acquired, perhaps, through some secondary source.

first the forked End (b.c.) cant so Easyly follow, therefore if the body be light; and there be a sufficient number of these Attoms to carry it away with them tis attracted, but if the body be too heavy then (b.c.) like two little springs are bent close togather, and so can follow the [sharp] End, (a.) leaving the Immoveable body behind them. This Posture of the Channels they inferr from the alteration made by fire; for a magnet heated red-hot, if the poles of it be turned the contrary way and so it cools (they say that) the poles [of] the Magnet are Quite altered; but if it cools in any other Posture than polar, the magnet then is Quite Spoyled.

Magnetick virtue causeth Gravity
In its attraction, and Verticity.

A Cognate to Magnatism is Elatery; that is the power which Jett, Amber, Red-wax, etc: have of being rubed, to draw small motes to themselves. But this (say they) is not by Cœlestiall matter moved through the pores of these bodyes but by Volatile steames from themselves which stirred, and put in motion by the Action (or rubing) fly out every way in strait lines; and are presently in like strait lines prest back again to their fountain by the Atmosphere, Now being a little clammy, (as somewhat melted) by the heat of the friction they snatch up, and carry with them back those little Motes. These Elaterial bodyes being compounds belong to another place; only they are here mentioned for their Analogy to the Magnet from which they yet differ in that they

1. Have no verticity or direction to the poles.
2. Respect all little, and [easily] moveable bodyes alike.
3. Have no Virtue without friction, and therefore they
4. Act by Internal not External atomes as the magnet does.

Jetts Elatery Slights Magnettick Laws,
Unturn'd, [all] rubbing, and internall draws.

N.B. To this Magnatism of the Earth the Copernicans ascribe the Earths direction of its poles still parrallel to the poles of the Universe: though it thereby roles [sidewise] in most places of its annual motion round the Eccliptick or Great orb, whose poles stand another way (as is before noted.)

N.B. That metalline and magnetick bodyes, are here placed among the Simples, because they are supposed to be Elementary and first principles; whereas the Minerals, and loadstones which we dig up are indeed compound, and mixt bodyes (as our fire, Air, and Water also are as is before noted.) [We] cant actually come at pure Elements; however, because the Elements [or] principles of bodyes are Eminently Seen in these concretes we will Give them the name of Elements themselves, and handle them in the 1st Place.

Chapter 11

Of Mixt Body in Generall, and its Affections

HAVING Done with Cœlestiall bodyes, and terrestriall Simple, we come now to terrestriall mixt or natural bodyes of which in Generall, and Speciall.[1]

1. In General A Mixt is a natural body consisting of Elements (as matter) and the form of a mixt. Mixture is the Union of Elements altred (sayes Aristotle), [altered] not corrupted; for the Elements remain in the mixt bodyes but their Qualities are so broaken by the mutual reaction of contraries, and their matter so divided into minute parts, and Shuffled togather that they are not discernable apart in any mixt body. Union, or becoming one by virtue of one substantial form which comes over the Elementary matter so disposed and altered, and causes them so prepared to conspire in one mixt distinct from the Elements themselves, even as meal and Water mingled [become] dough distinct from them both.

Divided matter broaken Quality
Make Elements to Union comply

The Affections of a mixt as Such are Either Primary or Secondary.[**37**]

1. Primary Affection of mixt is temperament, a proportionable Union of the hot with the cold and the Dry with the moyst arising from due mixture of the Elements. This proportion of mixture may be considered either as Arithmetical or Geometrical.

1. Arithmetical, or Exact proportion is wherein all the Elements are Equall, and that either in Quantity, or Quality.

1. In Quantity, or bulck (as say 1 oz.) or by number of parts (say 5 of each) this cant be, or at least not long Subsist: for the Active fire in so great a proportion would soon consume the rest.

2. In Qualityes, Virtue or degrees of Efficacy, (as say of fire 1 oz., of water 1 oz., etc:) if this ware given in any body it would never corrupt, because the Equall Virtues could not overcome Each other to cause dissolution. Therefore the proportion of Mixture is in neither respect Arithmetical.

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[1] Most of the definitions and divisions in this section are based ultimately upon Aristotle, both the *De Generatione et Corruptione* and the *Meteorologica* contributing something. The discussion of temperament, essentially medieval in outlook, leads to the ancient medical works in the Hippocratic Collection as well as to Galen, and touches one of the most tangled problems in medical history.

2. Geometrical, [rationall], or Just, in which the Elements Differ in bulck or virtue according as the Special nature of each mixt dos require. This Proportion of [mixture] is Physical, and here intended, and is either Simple, or compound.

1. Simple in which one Quality is predominant over others.

2. Compound in which two are predominant, this according to the various combinations of first Qualities [constitutes] the 4 Complexions: 1. Sanguine; hot, and Moyst, 2. Cholerick; hot, and Dry, 3. Phlegmetic; Cold, and Moyst, 4. Melancholy; Cold, and Dry.

N.B. Complexions are Cheifly handled in Medicine with their proper signs, and Inclinations to deseases, (of which Lemnius[1]) as they belong in Special to humane body: But in Analogy they are ascribed to many other things; as, in other animals, and Plants, both in respect [of] their own Vitall-action, and of their Use in [Physick], or Medicine: In times to the hours of the day, Seasons of the year; Periods of Mans life; yea in fossiles Earths, and minerals in respect to mans health, or their own contexture. But this Attribute of complexion is with difference sutable to each kind, So as the hot, and Moist in minerals comes far short of the same in Vegitables, and [in Vegitables] of the same in Animalls.

N.B. This Temperament or complexion of the body from the natural spirits (after mentioned in their place) dos fit and incline the Animal to certain peculiar kinds of Actions, therefore the temperament of the body joyned with the habits, and customs of the mind do make up that peculiar Spirit or Genius that belongs to every man.

N.B. The word complexion ascribed to the Colour of the face, is not Phylosophycal, but Rhetorical, and is the name of the thing signifyed given to that which is but a sign thereof.

Complexions 4 Gives Spirits to Animals,
B[y] Analogie to plants time minrals.

2. The Secondary Affections of a mixt body arising from temperament are 1. Gust, the patible of tast; 2. Savour of Smell, 3. Colour of Sight. thus (the Antients) and why not 4. Sound the Patable of hearing [too?] tis so (in part at least) for we Experience that diverse materials yea without respect to their figures; yet yeald sound in Great variety. I should rather than exclude this admitt some of the patibles of touch, for if hard-

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[1] Livinus Lemnius (1505–1568) was author of *De Habitu et Constitutione Corporis* (Antwerp, 1561). As Mr. Morison notes, a later edition of this book was in the library of John Harvard.

ness be caused by cold, (as is commonly said) then this and its opposite Softness do depend upon temperament.

As Secondary Affections to a Mixt
The Patibles of Senses are affixt.

N.B. All these Patibles are treated of in the powers which they move, and by which they are Patible, [or] perceived.

N.B. All this of temperament complexions, and their Consequents is by moderns Solved by the Matters Variety, in the Particles, Figure, Motion, or Rest, etc: but however the thing be solved the Use of it is the same.

Chapter 12

Of The Species of Mixt bodyes, and of firey Meteors

MIXT is Either Perfect or Imperfect.

1. Imperfect is an Element but a little altered by some Aliene Qualities, and not attaining that perfection of temperament as may fitt it for a substantiall form (if such be) to give [it] a Quite distinct being, from that of an Element this is either primary, or Secondary.

1. Primary Call'd Exhalation or steam which is a multitude of Small bodyes lifted up by the reflecting sun-beams from the terraqueous Globe much as a ball licks up moisture or dust from the floor from whence it rebounds. tis [either] vapour or fume.

1. Vapour a moist exhalation raised by heat from the Water. [38]

2. Fume is a dry Exhalation raised from the Earth, Especially its more volatile constituents, Sulphur, and Niter Volatis'd, and broken into smallest parts.

2. Secondary made out of the former, [called] Meteor which signifies somewhat lifted up hung in the air, seen at a distance, tis either real or Emphatical.

1. Real, or Substantial is 3 fold, Fiery, Airy, Watry.

1. Fiery made of fume, and dry Exhalations which (say the Antients) is kindled by Vertue of the heavens, and heat of the Air, or by Antiperistasis. But (according to moderns) tis more probable that many Sulphurious, and Inflameable particles, being Scattered and hovering about in the Air meat with more of their own kind, with which combining, they make a mass of Inflameable matter.[1] to this, if particles of an Opposite nature occur, they cause an Emotion, attrition, or fermentation (as Water on unslack't lime; or as Spirits of Nitre, and tartar,) and this fermentation may so increase as to become a flame. This flame only continues so long as the Sulphurious parts are in combination, fitt for attrition; but when these are again broken very small and Scattered abroad it seases. The Frequency of these meteors as to certain times and places may depend

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[1] Both the *Meteorologica* and the *De Mundo* underlie Morton's comment on fiery meteors. Aristotle's notions have been modified markedly, however, by the seventeenth-century enthusiasm for nitre as an explanation for all kinds of atmospheric phenomena. This may be observed in Descartes, *Principia Philosophiae*, Pt. IV, in Boyle's *Essays of Effluviums*, and in a long-forgotten book by William Clark, *The Natural History of Nitre* (London, 1670), where Morton's explanation of thunder and lightning is paralleled rather closely. See also under *nitre* and kindred words in the *New English Dictionary*.

partly on the heavenly influences (according to their respective positions) whereby these Inflamable matters are Volatilized, and prepared for a more copious ascent; and hence parhaps tis that within the tropicks are more abundant, and Eminent fiery meteors: and Partly from their beds in the Earth where they are Generated, from whence they will not arise untill they are sufficiently fermented. Bread, Beer, Wine, Sider, Moist-hay, Carcases, etc: have all their several times which they require for the height of their fermentation; [and] these times are varied again according to the temper of the Air, and Seasons of the Year; with other outward Circumstances; add to this that Diverse parts of the Earth have Greater Quantities of diverse kinds of matter, su[c]h as minerall countryes, fossile Sulphur, Church-yards, places of battel, Dunghills, etc: have more of animal fatt; yea the sea itself may have its fish [oyle] floating on the top which the sun-beams also can Easyly lick up.

Nitro-sulphurious fumes from Earth do rise
And kindled fiery meteors supplyes.

Now from all these Varieties are the diverse kinds of meteors form'd or Inform'd.

1. Inform'd Such flames as fall under no certain Usual shape whereby fancy might give it a name.

2. Formed, and this is in the 3 several Regions of the Air, Viz: in the Lower, middle, upper region.

1. In the Lower region are commonly said to be 3 $\left\{\begin{array}{l}\text{Dragon}\\ \text{Foolish}\\ \text{Licking}\end{array}\right\}$ fire.

1. The flying Dragon of a Viscous, (or Clammy,) Crass fume inflamed and incurvated by some cold cloud in, [or] through which it passes not far from the Earth. Tis Somtimes Seen in a Cold Still night as a long flack of fire hanging in, or Gently passing through the Air, and not much unlike the Smoak that pases from the bowle of a lighted pipe of tobacco, or the smoak of a Candle newly Extinguished.

2. Ignis Fatuous, (the foolish fire) Jack with a lanthorn, or will with a wisp; tis (like as the other) crass heavy, and nearer the Earth, [only] lies more round togather. One alone appearing, (cal'd Helena, by the Superstition of the Antient heathens) was accounted an Ill omen, or Sign of bad luck: but two appearing togather, (called Castor, and pollux) prognosticated good in their oppinion; and hence [probably] the Apostles ship was so named, (Acts, [28]. 11.) as we now call ships Success, Victory, etc: This

foolish fire is said to lead men out of the way into boggs, and mires, because in a darck night a travelling stranger being not very sure of his way and Seeing a light may hope to approach thereunto to find an house or some man with a lanthorn: but bein[g] deceived he may find (instead of company) himself in a ditch; the Amazment whereof doth sometimes so bewillder him that wandering all night and finding in the morning he has made no progress the mans fear (proceeding from Ignorance in this point) makes himself Phancy a Misguidance by evill Spirits.

3. Ignis Lambens ([the] Licking fire) is an Inflammation of the Steams proceeding from the body of a [Sweating] Animal; which (without hurt) seames to hang on the Cloaths, or hair so as not to be brushed off, because tis stil renewed by continuall Steams. It happes most when men have drunck hard, and then in a Still dark frosty night, ride hard to make hast home. The first inkindling is (not only by the Antiparistisis if at all but rather) by some spark of a flint trodden upon by the horse, or a mans hob-nailled-shoe, Now as the steams of the spirits of Wine may easyly catch fire so may the vinous Spirits (known, and discovered by chymists to be plentyfull in the blood of any animal) when they are in any considerable Quantity sent out by Perspiration. hence tis probable that this happens not to all men in such Circumstances, because all men and horses have not the same Vivacity, nor are Chafed by Such Mixtures of fear, and boldness [39] as may be requisite for such Inflameable Immanations.

2. In the Middle region are the falling star, burning lances, and thunder.

1. The falling Star or Star Shooting which was antiently supposed to be a more compact and Globous matter inflam'd in those parts of the Mass that ware inflamable and the rest being Earthy, and Watry fall down in a Cold Jelly (like blew starch, boiled) which is often found in the feilds, and is called Starshot.[1] Tis said to be good for burnings; 'tware worth the while Chymically to examine its composition, that we might make a better Guess at the Nature thereof: for indeed what has been said about it hitherto [does] not well Satisfye; for, Why is not the Inflamed body seen before it shoots? Why Inflamed only when the Air is inclin'd to rain, So contrary to Inflamations? Why dos not one fall burning in a longer tract than another? and lastly Why is not one more notably bigg than another, since tis not probable that all in a night have so near an Equall [quantity] of inflamable matter? It seams therefore more likly that in them is [no]

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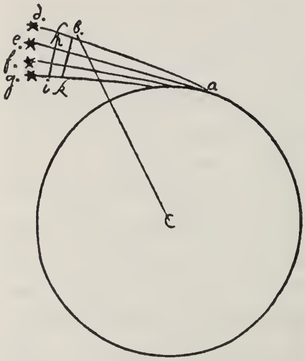
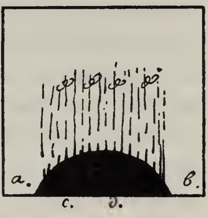
[1] Mr. Morison has indicated the background of Morton's error here; see also under *nostoc* in the *New English Dictionary*. Star-shoot was one of the early subjects of investigation by the Royal Society. See a letter from Henry Oldenburg to Boyle, November 10, 1664, in Boyle's *Works* (1772 ed.), VI. 174.

matter [inflamed] at all but tis the Suns light reflected by the Gellatine body to our Eyes; as in Glow worms, Jelly of putrid [fish], Cats Eyes, Rotten-wood, etc: which may be thus conceived. Suppose some Earthy particles Intermixed with watry which are nearly disposed to fall down in rain some of these Earthy particles in the Upper part of the middle region are moistened, and thereby stick [to others], which they meat with of their own kind till so many are Joyn'd that they cant be upheld any longer by the Weight of the Adjacent bodyes; then must they sink and begin to fall downwards, and in the fall many more are added, till they become that Mass of Jelly which we find; at the first falling they are too small a lump for reflection of the suns light at such a distance, and therefore [they] are not then seen and in the Period of their fall they drop into the dark shaddow of the Earth, and So having no light falling on them can reflect none back to our Eyes; and hence probably there are none seen to fall from that part of the heavens which is [directly] opposite to the Sun because they come down all the way in the [Shade] nor from those parts which are near our twilight; because though they have light enough [upon them] yet they discend in a line so respecting our Eye; as not apt to reflect light upon it; but another way nearer the Horizon where the twilight is; for that the Angles of Incidence and reflection must be the same. The appearring obliquity in their shooting, [or] fall may be for that the line wherein they discend directly towards the Center of the Earth is oblique to the Scituation of our Eye; Now we having nothing but the Stars to compare to that line of discent, it may Easily impose upon us. As Suppose (a.) [the eye] on the Surface of the Earth (b.) the place of the Jelly, which fals towards (c.) by the line (b.c.) In which fall towards (c.) the Center of the Earth it intersects the Several lines between (a.) the Eye, and (d.e.f.g.) several stars which are far above it; hereby we perceive not its coming nearer to us, but fancy it to fall in the line (h.i.) parrallel to the line (b.k.) which is all one in appearrance for nearness, and distance is not perceived by the Eye, but where there is somthing intermediate, or by the side to be observed. And therefore the Impu[l]se by a Cloud (which the Antients talk of,) seams vain the rather also for that Star shooting is most common when the heaven is Clearest, for as yet these watry steams are not condensed into clouds. So that we may well strick off this falling



star from file of fiery meteors, and may rather call it Earthy. This appearrance is most common in the summer time when the Earth sends forth more plentifull Effluviums.

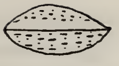
2. Burning lances, these in a dark night I have once seen in Essex arising out of a very Dark Cloud which seam'd to be a segment of a Circle appearing above the [North] horizon about 20 degrees, as suppose (a.b.) the horizon (c.d.) the Darck Cloud, (e e e e) the burning lances which stood not in one state, but arose some behind the rest (like a company of pikes in a Counter March) Somwhat Suddainly start up to 50, 60, or 70 [Degrees] and some fall down again within 10 of the Cloud, and then Er'e long disappear, and all this appearrance was as bright as flame.



The Cause might be the Swiming of Sulphurious parts [above] a thick watry cloud which being there inflamed and having no h[u]mid above them (which might have caused [40] thunder) they freely blazed up in the Several places where the matter lay. Now, that they Ascended up so small tis probable 'twas for that they were above the Atmosphere, and So there was no pressure to hinder their ascent. Else their flames should have been broadned below and Joyned one to another, thereby making one Great blaze, as we see tis in our Culunary fires.

3. Fulmen, (we want a proper English word for it) whose Sound is called thunder, and its light coruscation, or Lightening. Tis made of 3 principle parts Sulphur, Niter, and Water, and Somtimes there are Earthy, Sandy and Minerall steams among them, the matter of which is cal'd the thunder-bolt; the manner how these are made may be conceived thus. [There being of] The 3 principle Steams, great Quantities raised, and held up the Sulphur, and niter (those Ingredients of Gun-powder Emulous of thunder) in a Sufficient Quantity met togather begin to ferment, and to work upon Each other in their Struggle they beget heat; this draws more Steams to them, first of their own kind (because more volatile) and [afterwards] of the Water; hence we see the thick clouds to gather and conglomerate [all in] one place, as if the Wind blew from all Quarters when indeed there is none Stirring: These Clouds are now fully dispos'd to falling rain, but are held up by the Attra[c]ting heat of the combustion (as you see the steams of water set on the hearth will draw towards the fire which is done by the [fires] Circulating parts going to, and returning from the Center) the two Active principles (Sulphur, and Niter) being thus enclosed by the Antiparistasis of the Cold clouds augment their heat till some parts which are most heated take fire, and then seek more room for

their flame to Expatiate itself in; and because it cant find space it makes way through the thick Cloud whose parts thus Seperated yet pressing [hard] togather, as soon as the flame is Gone, fall one against another, and from that vacuity thus filled, Issues the Thundring bouncing sound. Now because the Cloud is broken but part by part therfore the Sound is continued in a long Series of bounces, and these Greater or less as the Clouds make resistance. The like may be observed in a Great hot Iron, when Quenched in the water of a Smiths forge, for then in Cooling the fiery particles pass off, and break through the water; though not in a flame. In a Gun the flame is better seen, but [then] the bounce is single, because the flame presently dilates itself every way when tis out of the streightening of the Gun the Atmosphere being heavy enough to make one bounce but not to keep the flame, and its parts togather, and hence it follows that if a Gun [were] Shot of[f] in a thunder Cloud it would repeat its sound like [the] thunder, and if shot above the atmosphere twould yeald no sound at all. When the flame breaks out of the Cloud downwards we see its light Immediately; but the Sound though it be formed at, or before the flame breaks out, is somewhat longer in coming according to the Distance of the Cloud, of which Distance an Estimate may be made by the measure of a pendulum compared to the distance of a Gun shot off and the space between the light and sound. After the fire and Sound and another distance of time comes down the broken Cloud in a Shower; for now the heat of the flame holds it no longer up, the water indeed sets forth togather with the light and Sound, but cant break its way down through the Atmosphere to come to us with the like Expedition. If all the Combustible matter fire not at once (as it very rarely dos) then the Lightening, thunder, and rain are repeated again and again in Several flashes, Claps, and Showers, Untill all the Inflamable matter shall be spent. If the Cloud breaks downward then beware the Earth; for then the lightening oftentimes burns higher buildings, blasts plants, and hurts Animals; and White lightening is accounted most daingerous, as the white heat of Iron is hot in a higher degree than the red or yellow, if the Cloud break upwards we have thunder without lightening, If the Cloud be not very cold or moist we have lightening without thunder, as in summer Evenings after extream hot days and this (as indeed all lightening whither with, or without thunder) is of Excellent Use [for] Clearing the Air If among the Nitro-sulphurious parts are any considerable Quantity of [Sabulous] Ashy, or mineral parts this is melted into Glass or metal by the Vehement, and brisk fire, and breaking out with the fire dos the work of a bullet, in rending trees, and slaying Animals this is cal'd the thunder-bolt which (though it



may come soft out of the cloud yet) in coming down it cooles and hardens Generally in a roll. The motion contributing to the figure [**41**] (as in the margine.)

The blasting lightening where it burns not seam[s] to be from Vitriolick, Arsenick, or Other Corrosive steams, which flung with Violence, and Vehemence by the lightening and in small parts do somtimes Enter the Garment without [Change], and yet hurt the body. The turning of Liquors Sour by thunder is no other than what may be done by bels, Guns, Drums, or other Vehement Sounds: whereby the Smart percussion of the Air causes all the Vessels and Liquors to Vibrate which Does so allter the site of those minute, and volatile parts, (that preserve the liquor[s] by their ordinary Circulation) as that they cant do their Office; and the Same concussion also gives motion to the Corrupting parts which before ware Quiet in the Lees. As for other Effects Such as balls of fire, flying like canon-bullets, or running up, and down an house, and doing Mischeif in an Extravigant manner; because no sufficient natural reason can be given [for] them, they are ascribed to the power of the prince of the air, by divine permission. And So much for meteors of the middle region.

3. In the Upper region are such as beginning to be [Inflamed] in the Middle region do ascend above it and [there] shew themselves as a rocket gets aloft and there burns out; such are accounted 6 (but 5 only are true) Candle, beam dart, Kids, Spark[s].

1. The candle So called from its likeness, [one] such I have seen (in Surry) blazing like a torch about 25 degrees above the N. Horizon in a Summers Evening, and So continued in the Same place for a minute or two after mine observation, and then falling Extinguished; lik[e] a flaming drop falling from a torch, which goes out before it comes to the Ground.

2. The long blaze if it lyes Horizontally tis cal'd a beam (seen once by my friend Mr. N.B. in Cornwall.) If perpendicular tis cal'd a pillar (seen by Mr. W.W. Near the river between Cambridge, and Linn.) The lower End at length discending to the Earth, where it Distroyed some Acres of Growing pease; The reason of these may be the meeting of [two] firey meteors passing two Several wayes, (as the winds which make a Whirl-puff) and So the Inflamed matter shews itself (as the dust [that is] lifted up by the Whirlpuff.)

3. The [Dart], So caled from the motion more than the figure. Such as I suppose was that ball of fire in February in 1675, between day and night which flew over Northamptonshere, Bedfordshere, [Harfordshere], Middlesex, Essex, and the sea leaving a [Stream] of light in the place

where it [had] passed, which continued 4 or 5 Minutes after it was gone. The Reason of it may be guessed by observing a Rocket which flyes from the End of its inflamation; It may therefore be conceived a Mass of Combustible matter mixed with other Glutinous Stuff not So combustible this may cause it to burn Gradually, and fly from the Side which was first Kindled.

4. The Skipping Kidds consist of many fumes, of unEquall Density which hovers in the Air, (like the Smoak of Tobacco.) So as the more dence being Kindled, shew themselves as a flame; and the more rare serve only to convey the Inflamation; to another Denser part, with which it is continued (like as the light of a Candle Newly blown out, by its fume only touching the flame of another candle is [revived]) and thus the flame skipping as it ware to, and fro like to a frisking Kidd thereby [obtains] its name.

5. Sparcks are when the matter is more dense and dissevered in small parts Each from other like the Charcoal-dust that falls kindled from the breaking [of] a Rocket.

6. Comets (by the Antients) used here also to be reckoned but I think they are neither fiery, nor meteors, and therefore we shall treat of them in a Chapter by themselves.

Chapter 13

Of Comets

COMETS are Usually handled among the fiery meteors; but indeed their proper place should be among the planets as shall be Shewn, of these may be considered, the Matter, Motion, Distinction, place, Magnitude, and End.[1]

1. The Matter of Comets formerly suppos'd to be combustible is certainly not So; for If they ware fires it cant be conceived how they should last so long, or send forth a [Stream] one way [Sidewise]; or be of Such a dim Colour as Usually they are; or whence should come so much combustible matter? tis therefore more probable that they are either Gelatine mater (such as is spoken of before in the falling star) or rather Christalline [42] which partly reflects, and partly transmits the Suns light shining upon it; what it reflects Shews the body, and what it transmits shews the Stream, which is alwayes the Contrary side from the Sun, and is tinged partly according to the matter, but Cheifly according to the nearness, or distance of that [Line] which passes between the Sun and our Eye; Just as a Glass of Claret Wine Standing where the Sun, or a Candle shines upon it, If we stand So as we see not the Sun or Candle, we see then the body of the wine by the reflected light and by [the] transmitted on the side farthest from the Luminous body, a Stream coloured as [the] liquor is. This was manifest in that which was thought 2. or 3. Anno 1664; for at first it appear'd with its tail Eastward because the Sun stood west from it, thence it moved north East about [5] Degrees every Day by which means in some dayes it came to be opposite to the Sun, and then it appeared about midnight, as broad as the Moon having the streams not any one way but round about; After this twas Clouddy till the Comets pased into daylight, and So could not be Seen. About 2, or 3 months after it appeard again, a little before Sun-

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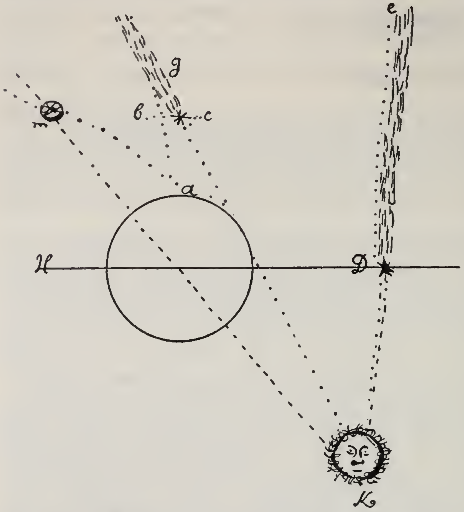
[1] Morton's explanations of comets show a rather curious use of sources. A great deal of his information comes from two books, neither of which can really be regarded as an impressive authority. Robert Hooke's *Cometa*, a part of *Lectures and Collections* (London, 1678), consists of rather disorganized remarks, from which Morton apparently culled much, including, perhaps, the figure on page 90. Hooke's book was included in his *Lectiones Cutlerianae* (London, 1679), which has recently been reprinted by R. T. Gunther in *Early Science in Oxford*, VIII. These are the Gresham College lectures to which Morton refers. The second source, John Spencer's *A Discourse Concerning Prodigies* (Cambridge, 1663), has about three pages out of one hundred on Morton's point, but more comes from those three pages than is suggested by the citations. See, for example, the note on page 92, below.



rising, and then the Stream was westward, (the Contrary way to what twas before) and much longer; because its being near the Horizon set it [Sidewise] to our Eye; whereas when it appeared near the Mid heaven, the train was foreshortened Standing farther off than the body. As in the Diagram; Suppose (a.) the Eye at the Surface of the Earth whose Horizon is the line (H.D.) at (c.D.m.) is the Star in several postures to the Sun (K.) that at (D.) under or near the Horizon sends its train upright, the Suns light (as to our Eye) being Just under it, and the whole length of the train appears the length of the prik't line (e.D.) but in the Posture at (c.) The Train stands oblique, the Sun ([as] to our Eye) So standing to it Here though the train be really as long as it was at (D.); yet to our Eye it appears not so Long; but as the line (b.c.) because of the foreshortening; So that though the train[s] (e.D.) and (g.c.) are Equal, yet the lines of their appearrance ([b.c.]) and ([e.D.]) are not So. Yea the Comet at (m) has its train not Seen at all as to length only Some of the breadth of it round about the Star. Now when the Comet was at (D.) near the Horizon, (where the Atmosphere used to be Guilded by the Sun-beams) It from thence appear[ed] more red (like Mars) whereas when it stood before more in the dark, as at (c.) it was of a Dusky blew, (like that of Saturn.) From thence it appears that the matter is transparent, whether it be Gelatine, or Christalline is the next inquiry; If Gelatine, and drawn to one place from elsewhere (as the Star Shot is) then the Supposal must be that the Jelly is Coagulated out of the Steams raised above the attraction of the Earth, (If from the Earth) and there hanging in a kind of Quiescence til some Aids come to cause that Coagulation, but then here are [divers] difficultyes to be Solved; as

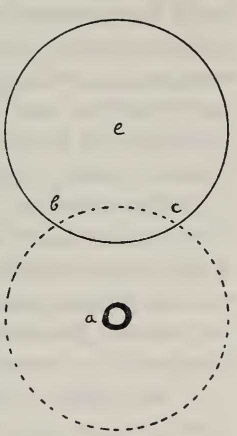
1. Concerning their Periodical motion how shall it have beginning? Shall it be by pressure [between] two thick Clouds (as a Cherry Stone [Spirted] from between ones two fingers, or water from ones mouth) if So where should these thick Clouds be? Not in the Upper region for there are no Clouds much less such thick ones [as required.]

2. Whence should all these steams arise? The Earth cant aford matter for Comets of such a Magnitude, as Some, (if not all of them) are.

3. Nor would [Earthy] matter rise to such a [Height], or wander so far from home as beyond the moon where some comets have been.

4. Nay All the planets if they did club for Such a mass would hardly Suffice without Sensible diminution. Therfore the most likly oppinion is that they are not meteors at all; but rather a kind of Christalline planets, Concreated with the Universe which have the Circle of their revolution excentrical from the rest; So that they Somtimes approach nearer to the Earth, and then they come into our veiw, and [so] continue [on] in the revolution untill by distance they pass out of Sight again.

Thus Suppose the little Circle (a.) [be the Earth,] the prick't circle about it is the dis-[43]tance in which a comet may be seen; If now the Revolution of the Comet be the Upper Circle about the Center (e) tis manifest it can be seen but while it passes between (b. and c.) Hence



N.B. That the same comet will return again in veiw after a certain period of time to ascertain which some Ingeneous persons have so dilligently observed the course of the last comets, that they have given their conjecture at the periods of revolution as is noted in the Phylosophycall transactions.[1]

2. The motion of the Comets is either diurnal, or Periodical.

1. Diurnal is Such as the Planets have appearing only by the revolution of the Earth about its own Axis (according to Copernicus) for to be Snatched about by the Primum mobile of the Antients crosses their own principles; for that tis not fixed in a Solid orb, and hath [no] intelligence to guide it being but a Sorry meteor, and this indeed adds no Small strength to the oppinion of the Earths revolution, as also [to]

2. The Periodical motion of the Comet, (or Christalline Globe) It must be according to its own proper circle of revolution. Therefore the Comet before mentioned Anno, 1664. must have the plain of its circle lying between N.E. and S.W. for so the motion of the Comet was from S.W. to N.E. (as is aforesaid) This is a hansom Solution of the p[h]ainominon, and possibly in hereafter appearing Comets men may compleat that work already begun (as is before noted) [in] taking a Skilfull and exact notice of a comets motion and Difference of its distances; whereby

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[1] See the first number of that journal, March 6, 1664/5.

a Segment of its Circle of revolution might be known, and thence also might be infer'd not only how long at present it would appear, but after how many years it would appear again.

3. The distinction of Comets into Crinite, Barbate, and Caudate Signifies not Several Kinds; [for] one and the Same may be all these (as you may see in the aforesaid Instance [of] 1664.) but the Different appearances of a comet are according to its Scituation, respecting the line between the Sun and our Eye; (as is before Shewn) when therefore it is nearer the Sun Eastward, the [Stream is] westward, and [then] tis cal'd the barbate because it stands before the body (like ones beard) in its Supposed diurnall motion, when the comet is nearer to the Sun Westward, then the Stream is east, and comes after its body (like a taile) in the Diurnal motion, tis therefore caled Caudate; but when the Comet is opposite to the Sun (and in the same meridian with the Azimuth Circle) then the brush of it is behind its own body, and from our Eye, and So its length cannot be Seen; [only the Light being devaricated by the refraction of the Christalline Ball, and perhaps helped by our own Atmosphere, the Rays appear round about it, and then tis called crinite, as representing the Bushie hair of our head. This is but seldom and not long Seen,] because the Comet Soon passes out of that position to the Sun, and parhaps may be Ecclipsed by the Shaddow of the Earth if the Comet be low or the line of position be Central.

4. The Place of Comets is according to [their circle of] revolution;—Some it Seams have their Center far remote, and therefore they have appeard among the planets. Possibly the New star in Cassiopeia (Anno 1570) might be of this nature. Others have their Center nearer and So Some part of their Circle [of revolution] comes below the Moon, and Somtimes very near the Earth, as is found by [their] parrallax.

5. The Magnitude of Comets might be known if their distance be ascertained; there are strange conjectures of many learned men about them. Ticho measured the train of the comet (Anno 1577) to be 96 diamiter of the Earth, 672000 Miles; Others say that of 1618 his beard was 382700 Miles; that is German miles each of which is four [or five] of ours,[1] and yet the body of the Comet is accounted much less than the Moon. [But] indeed it may well be doubted, whether the Exact Height, [or] bigness [of any] have ever hitherto been found because of the Un-

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[1] Cf. Spencer, *A Discourse Concerning Prodigies* (p. 15): ". . . Tycho measur'd in the tayle or train of the Comet, An. 1577 ninety six semidiamiters of the earth; and some astronomers found in the beard of that which shone An. 1618. the extent of 382,700 German miles."

certainty of [the] antient astronomical measures as Galleleus and of late Mr. Hooke (in one of his Gresham Colledge lectures) have shewn however saies Dr. Spencer (in his book of prodigies) our atmosphere is not above 80 Miles; and Say others the Distance of the moon is [179712] (that is near about 200000.) And yet the Comets are often above the moon; for their parrallax hath been found less; and if found below the moon then there is a space Sufficient to set them far enough above our Atmosphere. And therefore they must be vast bodyes to make Such an appearrance as they do; be sure too great to be meteors arising out of the Steams of the Earth.

6. The End of Comets hath been Guessed by their supposed effects; to prognosticate some Great evills to Some particular Country; So that they have stricken Great terror into the Vulgar; But [wiser] men see no satisfactory reasons for these Supposed Omens. They see that which is Said in this business is Grounded on [44] falshood, (or at least [uncertainty]) Namely that they are inflamed matter and that their smoake and Ashes pollute the Air. [But] All this is to be reckoned among [the] Astrological Vanities; as is largly Shewn by Dr. Spencer in his book of prodigies. The true End therefore may be of these things conceived rather to be somewhat like that of Ecclipses; to give men some light into the nature of the heavens; for we are sure by these that they have no solid orbs; and into the motion of the Earth, for without this their diurnall motion cant be solved; [lastly] and Cheifly to raise admiration in the minds of men, and that the rather by the rarity of their appearrance to convince us how little we know of the Universe, and So to magnifye the Creator.

Chapter 14

Of Aiery-Meteors

AIERY Meteors are all Winds whether above or below the Earths surface.[1]

1. Above commonly cal'd winds consisting of Earthy fumes which [ascend] by the Suns beams reflected are repelled by the Cold watry Clouds [of] the middle region, and being not able to discend because of the beams that lift them up, nor ascend farther because of the Clouds they are put in motion sidwise one way or other according to the Site of the lower Surface of the first repelling Cloud. Of this consider [the turning, ceasing, and Divisions.]

1. The turning which is by another Stronger wind raised in some other parts of the Earth. Hence upon the Change of [a] wind we see the Clouds going another way than that wherein the wind moves near the Surface of the Earth till at last the whole moveable matter is wrapt into one and the same course.

2. Ceasing is by spending all its fume in the motion beyond the repelling Clouds, where it has liberty to Ascend higher, and disperse itself, and then if the Clouds be heavy and Pregnent this obsticle being removed, they [still] fall down in rain, [else] not.

Earth fumes ascending stopt by Clouds is wind
turns by a stronger lets Clouds fall behind.

3. The Division[s] of Winds [are] in respect of [Strength, Time, line, and Purity.]

1. [In respect of] Strength, and Weakness [which] is according to the Quantity (more or less) of the fumes collected togather.

N.B. the Gentle breize that blows from E. to W. Within the tropicks (commonly cal'd the trade [wind]) is not so properly a Wind as the Whole Atmosphere, Slower in its motion than the [Earths Surface], In those parts under the Greater Circles, [for there] the Surface of the Earth must move 21000 miles in [a] day, (or 24 hours) which [is about 900 Miles in an hour; but this] Swiftness decreaseth in the [lesser] parrallels till it come to nothing in the poles. Thus we see in a Still air if a man Rides or runs Swiftly he feeles (as it ware) a Wind beating in his face, when indeed there is none Stirring, as he finds when he slacks his [course] or stops; So it is in this [case] for though the Earth Going about carryes the whole atmosphere with it, yet it being a fluid cannot So soon receive the Impression or continue [the] motion altogather so fast as the Earth itself in that part thereof, [and] therefore it seams to go the Contrary way; and this the more when the Sun arising rarifyes the atmosphere, makes it thinner, [and] lighter, and less adhæring to the Earth because all day the Steams are ascending; but in the Evening when the Steams fall down again or rise less they Stick more firmly to the Earth, are carried more swiftly with it, and near to its own course, and then (in the night) [they] have little or none of the breize, and for this reason also we have [no such] breize neare[r] the poles; Not only for that the Earths Surface moves more slowly [here] having a less compass to go in a day, but because [our] Atmosphere is more heavy and adheres more firmly to the Earth.

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[1] The information on winds follows Aristotle's *Meteorologica* and *De Mundo*, and Morton does not accept Descartes' variant explanation of earthquakes. Boxing the compass was a familiar text-book exercise; see, for example, the popular manual by Joseph Moxon, *A Tutor to Astronomie and Geographie*, first published in London in 1659. The explanation of trade winds and monsoons, a matter which interested Francis Bacon among others, is strikingly paralleled in a letter by Dr. George Garden which appeared in the *Philosophical Transactions*, No. 175 (September, 1685).

The breize within the tropiks is begun,
When Earth dos fluid atmospher out run.

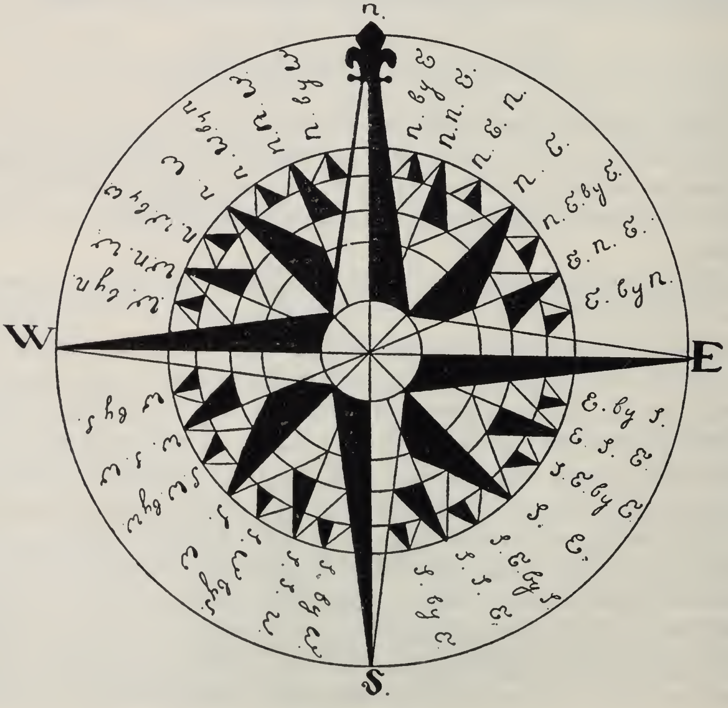
2. In respect of times, Stated, or Irregular.

[1.] Stated, or Certain times, Such as [our] March winds, May Storms, Michelmas winds etc: Caused by the Influence of Heavenly bodyes annually according to the Seasons preparing and [raising] the matter of [the] winds.

N.B. The [Monsoons] in the East-[Indies], with [their] following trade wind[s] ([blowing] one half the year N.E. and the Other half S.W.) must have their particular reason[s] which we cannot so steddyly assign, because we cannot be So distinctly informed of the Circumstances of Counteryes So remote [However] from what we have heard we shall offer [this] conjecture, tis Said that after about a months rayne the mansoons breake up or begin to alter [their course,] generally in October, that is the beginning of their Summer (on the South side of [the] line) and then they settle [45] to blow from N. E. for 6 Months [togather,] this may be answerable to the March winds, it being [our] Spring as October is theirs. Their Summer rarifyes [the] Atmosphere, and So the breize ([for that] the [Indian]-sea [lyes] about the [South] tropick [Line]) may have its Effect and communicate to them so much as is Easterly. The Vast continents of Asia and Affrica may afford Steams [for their continuance, and the vapours arising from the Summers dissolution of Snow in the African Mountains, may afford clouds, to turn the Steams Southwards toward] the Indian sea lying that way from them. Add also to this the bending of the mountaneous Ledg Going forth to the [Cape] of Goodhope all which togather may contribute to the [Southerly] motion of the Steams; these causes continuing may hold the Wind or breize N.E. for all the Summer, half a year; But in aprill (which begins their Winter) Either the Sun going [off] no[r]thward draws the Steams after it, or parhaps the Clouds which first turn'd it, may be dissolved, and discipated or rather the Vapours of the Atlantick sea may be so Great as to turn all the Steams the other way, and overbare the breize. And this may answer our Michaelmass Winds Which are Generally S.W. or at least westerly [and So continue] all the Winter long.

> From breizes steams, Clouds the mansoons are N.E.
> from the Atlantick vapours South, and West.

2. Irregular [winds (without Stated times)] are more accidental[ly]



various, and Unexpected, though they have their natural causes also but not So perceptible by us.

3. In respect [of] the [line] of the Winds motion and that [is] either direct or Circular.

1. Direct, [any] Strait line from any Coast of heaven and So they are discribed in the mariners compass to 32 points whereof

1. Cardinall, 4. E.W.N.S.

2. Collateral all the rest:

Now for getting this [easily] into memory, I recommend the division of them into

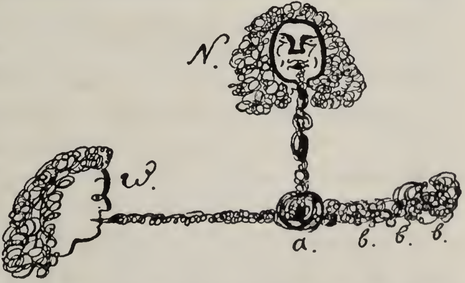
1. Whole Winds (the 4 Cardinal[s].)

2. [Half Winds] (the 4 middles) N E: S E: N W: S W.

3. Quarter Winds (the 8 Middles between the Wholes and halfes) as N N E // E N E // E S E // [S S E], etc:

4. By Winds 16. Assigning 2 to each Whole and $\frac{1}{2}$ Wind one upon Each side, as N. and by [E.], N E and by [N N E], etc: Also the Compass useth to be learned with application to time giving [to] Each Point $\frac{3}{4}$ of an hour; Saying N and by E. $\frac{3}{4}$ of an hour, N N E. an hour and half, etc

2. Circular winds (Called Whirlwinds) [caused] by the meeting of 2 Winds from Diverse Quarters that are of near Equall strength which when they hinder [one anothers] progress they both joyn in turning round, and So become Stronger than either of [the 2] apart. These Usually lift up things from the Earth, because more of the fume rushes in still from each wind into a narrow space till it can no longer [contain] it, then having still motion it must goe one way or other Downwards it cannot for the Earth; [nor] forwards [because] Each obstructs the other. Therefore upwards is its freest course, where the fume has rome to diffuse itself, and So it Ends. Yet besides the Circular it has Somwhat of a progressive motion for a while which is determined by the [Stronger] of the 2 winds. [As Suppose (N.) the] North wind overpowered by [(W.) the Stronger west] wind [do cause] the Whirle to begin at (a) then they have their progression [in] the course (b b b.) because [(W.)] is Stronger then [(N.)] but if the winds ware Supposed to be equal exactly in Strength [then] would be no progression but only ascent. **[46]**



Direct wind[s] are sea [compass] whirle winds blow
When two winds meat both [round] togather goe.

4. In respect to the purity or mixture, [This Mixture is] with fire or Water.

1. With fire (Called blasts) which may be conceived to have a mixture of Nitro sulphurious particles; which in [the] ascent before they come so high as the place of thunder are snatched aside by [a] wind, and thereby Vehemently impressed on plants, or animals, and dos them hurt especially in their more tender parts as in the buds, leaves, or blossoms of plants, and in the Eyes of Animals.

2. With Water (called Storm) tis when the abundance of Watry Clouds press low, and Streighten the wind[s] into a narrow Space; whereby the matter of [wind] being more dense becomes more vehement; and being mingled with some of the rain which can be no longer held up, [it] falls, and [presses] more heavily on bodyes that Chance to stand in its way this is mischeivous to Ships not only by its force but by moistening the Sails, it makes them hold wind the more, and by wetting the Cords and Decks makes them slippery, and beats the men from their work. And thus much for winds above the Earth.

[Blasts mixt with fire hurts plants and Animals
And watry Storm grevious on Sailor falls.]

2. Under the Earth in the Caverns thereof are [also] winds raised and included Commonly cal'd Earthquakes from the Effect [thereof]. The Production of these may be thus conceived, the Earth in its looser composition hath air [and] water intermixed, and these togather fill all the Space within the [Earth's] Surface. But upon the Accression for the Stone Sticking [closer] to the rocks, [there] must [be left] cleffs [or] spaces which become the Allimbicks [for] fountains in their ordinary Use (as is before noted) but when the steams [that arise in them] are [too] hot to be condensed to water which may happen either from certain influences of the heavens or from extraordinary fermentation, or from the disposition of the matter steaming, and being so sent up in greater [quantity] than can Evaporate, and being also agitated by [their] Greater fermenting heat, they Vehemently seek an outlet, and meeting with obstruction therein, they rush violently [where they can] in those caverns, and [cause] the Adjacent parts of the Earth to Shake in diverse [manners]. [Hence they distinguish] Earthquakes into [the] stroake, and trembling.

1. [The] Stroake whereby the Surface of the Earth is moved upwards, and downwards.

2. The trembling whereby the motion is forwards, and backwards horizontally; both [are] according to the Site and [figure] of the Caverns and the motion of the Exhalation; the Issue of [this is] breaking forth either in the many outlets of Springs, or in [some] one place by rending the Surface and making a Great Chasm [in] the Earth. This if it happens [in] the Sea throws up [those] wonderfull and daingerous Spouts, common in some seas, but If at Land it somtimes distroys Sityes, and overturns mountains, [and] removes them [intire] out of their [place]. These things happen most in rocky, mountain[ou]s, and mineral countryes and are commonly accompanyed with Subterraneous noys (like [that of] thunder,) by the Impetuous stroakes of the Exhalation against the sides and Ends of the Caverns.

In Subterraneous caverns winds do frollick,
When Mother Earth is troubled with the Cholick.

Chapter 15

Of Watry Meteors

WATRY meteors are made up of Vapours or moist Exhalation [licked] up by the Sun-beams rebounding from moist places, and carryed up to the middle region of the Air, or at least toward[s] it where they are again cooled, and condensed, these [Meteors] assend no higher, and therefore are all in the middle or lower [region].

1. In the Middle are 4. Cloud, Rain, Snow, haill.[1]

1. Cloud a multitude of little bubles of Water, Each filled with a particle of fiery matter which [bubbles] while they are at Some distance one from another they are not broaken but swim about in the Air, of these [clouds] some are said to be [Sterill, some pregnant.]

1. Sterill, or barren is when these bubbles are at a greater distance [47] and less in plenty These Clouds are White and yeald no rain. But the Woolsacks [(as they are called)] in August soon Change their Collour (by access of more vapours) and pour down rain, somtimes too much for the harvest labourers.

2. Pregnant of showers [(on the Contrary,) many] bubbles Close set, of a blackish hue and in next disposition to rain.

2. Rain is water falling down from these fertile clouds when many of the little bubbles are thrust Close togather, whereby there is an arrest upon their motion; this being not agreable to the Agile fiery particles it breaks the Enclosure, and gets away; then the Sides of the bubble falling togather, it can no longer Swim in the Air, [it] falls down, and one (parhaps) in the fall breaks many [more] that stand in the way, and so they come down togather. All the business of Clouds and rain may be apprehended by considering the Steams of a Pott, Sticking Close togather in little drops on the Cover. And the like [in the art] of distillation, which Emulates, (or Imitates) the work of nature, hence [that] Motto of London Distillers (out of Deuteronomy. [32]. 2.) Drop as the rain and Distill as the Dew.

[Bright Sterill clouds, dark pregnant pooles do fill,
From these wise Nature doth the rains distill.]

Rain is either prodigious or Natural.

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[1] Here again the *Meteorologica* and the *De Mundo* are basic, even though Morton makes much of nitre and nitrosulphurious particles, as in Chapter 12. Mr. Morison has noted that the discussion of ice owes much to Boyle's *Experimental History of Cold.*

1. Prodigious [(as tis call'd)] or Unusuall; [Such as] of Frogs, blood, etc: many of which are fabulously Storied, and what is true in Effect have not their probable causes assigned; by Instance in 2 or 3 you may Guess at the rest.

1. Frogs Supposed to drop from the Clouds, because somtimes, and in a particular place multitudes of little froggs are seen Immediately after [a shower] none being observed there before, which may be thus solved; The frogg-spawn of some adjacent pool being come to [the] maturity [of] having legs creep out of the water, into the Grass, and parhaps in the Coole of the night get a pretty way from the pool so as not to find the way back again; now tis their [interest] all the day to avoid the Scorching heat of the Sun, [and therefore] to ly as close the roots of the Grass as they can thus they may shade, and feed themselves for some dayes till a lusty Shower falls which invites them out of their lurking places to play and Skip about [in] their connatural water.

2. Bloud, or Inck (so called) because [the drops are of those colours which] have sometimes fallen on Stones, cloathes, etc: Usually in a small Circuit of place, the reason may be thus conceived; Some [Mineral], or Vitriolick Steams have been lifted up and hung in the Air till a Shower washes them down and the drops becom tinged thereby, as we commonly see water variously Coloured by infusions well known to Chymists; and most notable in that Circumforaneous water drinker who pouring down Clear water, would by Vomiting render variety of colours in diverse Glasses, that received his returned water; this was done partly by Somwhat in his mouth as a bagg of log-wood, a bladder of brandy etc: and partly by [the rinsing] of the Glasses with Severall kind[s] of Acid liquors (as Vinigar, [Spirit] of Vitriol, Solution, of [Allum], etc:) [all] which before the water came did disappear [in the glass].[1]

3. Star stones found in abundance near lead mines after a great Shower which indeed conveighs them not thither; but washing away the Dirt [only] discovers them to our [view].

4. Wheat (or other small things) may be snatched up in one place [by a whirlwind], and [soon after] let fall in another, and then it as really

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[1] The "circumforaneous water drinker" is mentioned by Boyle in his *Experimental History of Colours* (London, 1663; *Works*, 1772 ed., I. 772). Boyle says that the tricks of "those mountebanks that are commonly called water-drinkers" had been exposed "in a little pamphlet printed divers years ago in English." The editor has been unable to identify this pamphlet, but Morton obviously got his rather full information from some other source than Boyle. The trick is described, with somewhat differing details, in *Sports and Pastimes: or, Sport for the City, and Pastime for the Country; with a Touch of Hocus Pocus, or Legerdemain. Fitted for the Delight and Recreation of Youth by J. M. Amat. Ant.* (London, 1676).

rains wheat as the Gentlemans fool saw it rain beans and beakon. But indeed if there be any true wonders in this kind for which a naturall Cause has not [been] nor cannot (with Satisfaction) be assigned we may either acknowledge an Immediate hand of God [therein] (as in the raining fire, and brimstone on Sodom, etc:) or in a humble Silence Set down and meditate on his infinite power and wisdom.

Prodigious rains of froggs blood, Stars, and Wheat
Upon the Vulgar wits do put a Cheat.

2. Natural [rain is that] for which a naturall cause may be [given] of this note the kinds and Effects.

1. [The] Kinds, and that either from [the Number, or magnitude of rain drops.]

1. The [number of the rain drops] much or little [is] according to the Quantity of the prepared vapour.

2. The Magnitude of drops [is] Small, from [on high, as in Spring Clouds] when the [height] of the fall Splits the drops in peices; the like we see in the spouts of high buildings, [on the contrary] Great [drops are] from [low] Clouds, as in the declining parts of the year when the steams dont rise so high.

2. The Effects [of rain] are too well known to be enlarged on, only that of causing plants to Spring deserves [a] Speciall notice, and may be thus conceived. The Nitre and Sulphur of the Earth Volatalized, and ascending is by [the] rain dissolved and So made fit to Enter the pores of the [plant]; by the Same [rain] also are the superficiall crevises of the Earth stoped, So as the nitrous and sulphurious steams dont exhale but [rather] find their way through the plant[s]; then through the Earth beside it, but when the Sun has Exhaled the Water again [so as] the pores of the [Earth] are opened, [then do] these steams get away to be-[48]come the matter of thunder, and leave the plant to languish for want of nourishment.

Rains Kinds are Quantity, and magnitudes
Effects plants Growth while steam dissolves in [clouds]

3. Snow is a Watry meteor discending from a watry Cloud prepared for rain but meeting with much nitre it is coagulated thereby, and falls down [in flakes] white to a proverb. In hot Countryes is no Snow not for want of nitre in the Air (as appears by their Great thunders) but [because] the Strongly reflected sunbeams [melt it before] it [comes] to ground hence upon the tops of highest mountains [Snow] is found [even] in the hotest countryes, and here in England (I have observed) that the

same dark Cloud has afforded plentifull snow in the high mo[o]res of Davenshere, and at the same time abundance of rain, and no Snow in the warmer south hams, within 10 miles distance [of the Moores].

4. Haile is a farther degree of the same Coagulation, even when the rain has begun to [fall and been] formed into drops. This may be either by [Greater] Quantity of Nitre or [by] longer stay of the Water with it, or by a Stronger impression thereof by some Wind thereupon. And hence may be those hail showers somtimes in [the very] summer which are alwayes accompanied with [a] brisk no[r]therly wind. as to [the] magnitude more than ordinary it may be from falling far and Gathering much snowy matter about it in the fall, as [we see] snow balls are farther increased by rolling. But for the Prodigious hail mingled with fire on Egypt (Exodus. 9) and the Great hail stones cast down on the Armies of the 5 Kings of the Amorites (Joshua. 10.) and Such like; No Phylosopher must pretend to Explicate seeing [the] scripture ascribes them to the immediate hand of God, as Instances of his transcendent Glorious power, and execution of his righteous judgments upon his Enimyes.

While snow from Nitre has its Generation
Hard hail its rise from more coagulation.

Thus much for watry meteors of the middle region.

2. In the Lower Region are some watry meteors as Mist, Dew, hoare, Ice.

1. Mist [is] a Great Quantity of Vapour the same matter [with] rain not raised high enough to compleat that work but hovering nigh the Surface of the Earth The appearance of [mist] is commonly before [and] after rain but [the rain before which it is, is] not presently to Succeed [but may be deferred] (perhaps 3 or 4 Dayes or more) because the matter is not as yet sufficiently prepared. Such mists are those in the mornings about the latter end of August which commonly Cause Great rains in the End of September; and whereas they mostly Vanish in [the] rising higher from the Earth by the Suns heat (and So [presage] for the present a fair and hot day) this is because their parts in the Circumferentiall ascent have more room to seperate, and So become little clouds, [which] by Greater, and greater Distance at last [do utterly disappear] according to the rule of opticks, [yet there they are, and] tarry till more [of their fellows] come to them [which] joyning all togather become great Clouds again, [these being] aloft [and] keeping off the Suns rayes from us [do] Cool, and Chill our Air and at last fall down into rain. By this consideration [we] may solve that unusuall [and] (to some) frightfull Darkness

which happened between 10 and 11 in the morning of [the] lords day in January 1679 over many parts of the City of london.[1] A very thick mist arose in the morning twas cleared from the Earth about 9; [and] at the same time the Sityzens kindled their Coal fires to dress their [Dinner]; the thik smoak ascending at first was choaked [by] the [great] fogg that was spread abroad over the tops of the houses. Thereby the Smoak also spread itself under the Mist and caused the darkness which appeared riddish against the Windows, Soon after a little wind arising in the N.E. Carryed off the mist, and So the darkness removed by degrees toward Lambeth and Clappam etc: and [so] after a while the Mist arising higher by the heat of the Day gave way for the smoak to ascend [also], and [then] the Darkness wholly Vanished. After Great rains mists are common in the Evening[s] being only the steams of the rain from the warm Earth these having so weak a cause to raise them ascend not far but fall down again in dew, and hence they are commonly prognosticks of fair weather.

Mists in the Morning many Clouds do gather,
for after rain evening mists shew fair weather

[2.] Dew is a diminitive rain the steams being raised but a little from the Earth by the Dayes heat, [and] are condensed by the nights Cold and So fall down again to the Earth. In Egypt tis Sayed to Supply wholly the defect of rain, and indeed in all hot countryes they are very great where the sensible temper of the atmosphere, in the Day and in the night time are very disproportionable. Dews are either [Pure or Mixt].

1. Pure [is only] watry Such as [rise and] fall any time of the year when the night air is undisturbed with wind.

2. Mixt with some other Exhalations the most Eminent of this kind are { [Honey]
Manna [49]

1. Hony or Mildew is the steam[s] of flowers and plants spread in the Sumers Air, and mingled with the Ordinary Dew falls [on plants. This mildew] according to the plants it falls on is either hurtfull or advantageous.

1. Hurtfull to corn in little Enclosures near high trees, and hedges, and in very fat, and rank land, for there the mildew is drank in by the porous stalks before the Grain is perfect, and full and Stops the passage of the juyce which should nourish it. This Malady of Corn is call'd the

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[1] Mr. Morison has shown that this is the latest event mentioned in the *Compendium*, and the best evidence for the conclusion that Morton composed his book about 1680. As has been suggested, however, certain allusions hint at additions or revisions as late, perhaps, as 1685.

rust, whose best prevention [natural] is wind, or rain by streightning or filling the pores, or by Shaking or Washing [off] the meldew. Artificially, [there] is [Sometimes] Used a rope stretched by two men in a foggy morning and drawn gently over the Corn to brush away the Dew.

2. Profitable, what falls on other plants, that drink it not in but hold it out till the Sun [drawing] off the Superfluous Moisture the remainder is perfect hony. Such are the Oake, Hazell, Alder, etc: from whence [the] bees gather their hony and carry it home for their winter provision.

N.B. Hence it follows that bees make not hony, but find it; though tis possible [that] by their warmth in the hive it may have some [perfective] digestion.

N.B. Hence also tis a Vulgar Error that bees gather hony from flowers, for that which they gather from them is but a mealy Exudence, and is called Sandarack, and is [their] Spring meat for [the] Nourishment of their young before the hony season [comes]. This they bring home sticking [it on] the Down of their thighs [and that] only in breeding time. but hony they Carry in a bag within their bodyes, and wax (which is the Gum of certain plants) in their mouths; we may therefore Say Hony is from all flowers gathered by the Sun, and dropt on Certain leaves where the bees find it.

[Meldew from flowers hurtfull to Corn we See,
But profitably Gathered by the Bee.]

2. Manna is supposed to be the same Exhalation of flowers but concocted more, and concrete[d] by the Greater heat of the Sun; and tis not improbable [that] some peculiar mineral steams proper to the place dos help this [concoction]; from whence parhaps it may have its purgative Virtue; and that it is found in some particular and not in all places of the same climate. 'Tis found in some hotter countryes on a certain Kind of Ash, only Distinguishable from other[s] by this Effect. This tree dos not only hold [up] the Manna (as other leaves do the hony) but probably affords [also] some Exudancies to help [the] concretion.

N.B. The Manna wherewith the Israellites were fed was quite different from Natural Manna, [for]

1. That melted with [the] heat, this hardens.
2. That was food for all Ages, Sexes, and constitutions; this Solutive medicine for all
3. That fell only 6 Dayes (not on the Sabbath) [ours] fals indifferently at all times.
4. That was Ground in a mill or beaten in a Morter; this needs it not.

5. That Corrupted in a day; this lasts a Year or more, but if there ware somthing of the nature of manna in it, yet [tis manifest] there were many miracles about it.

[Our Manna's natural; But Israells Strange;
Melted, food falls not Still, ground, apt to change.]

3. Hoare is but Dew frozen; Sign of rain.

4. Ice is water congealed not in the Air (as Snow) nor in drops (as hail) but in the [Still Water on the Earth:] tis done as the Other coagulations by the [Nitre] of the Air. So Judged by the freezing of snow mingled with salt even near the fire as we commonly know the manner is thus conceived, Supposing the Watter be Externally Quiet (Whence the Still parts of the rivers are [frequently] frozen [when the rest are not]) the particles of Niter in sufficient Quantity are [thrust] (whether by weight or figure) into the pores of [the] water So as to obstruct the motion of [the] Internal particles and thereby removing its fluidity, yet before the Work is compleated it meeting with some other and [adverse] particles in the Water (perhaps Sulphurious) there arises a Contest, a Small fermentation, and Ebullition, Whence bubbles arising [and] yet Stayed in their ascent are lodged in the Ice, and thereby Swels [its] bulk herby taking up more room than the water of which it was made it has diverse Effects Such as breaking of [full] bottles [when they] are Close Stopt; allwayes [Swimming] on the Surface of the Water, and if thickned by snow falling thereon it makes the high floating Islands of Ice met with at sea by No[r]thern Navigators. There is one P[h]ainomina that crosses this Hypothisis, and that is the little water that Stands in horse-tracks, Cart-tracks, and other small puddles, in hard frost have but a [little] thin skin of Ice at [the] top under which is an Empty Space, all the Water being Gone. Now this would make a man suspect, that as in condensation of Stone, or drying of Clay the parts Shrinking one from the other leave the hollow cleft between. So the water condensing rather than dilating in the Upper part [shrinks from the other part] of the Water, [which is also condensed] among the [Earthy parts] at the bottome. **[50]** But tis probable that in Ice the Case is not So, rather the upper part of the little puddle being frozen, and the Ground [both] about it, and under it [at the same time] being smitten with frost, the Moisture of the Earth in freezing dilates itself, and rises upwards, and because the Earthy parts cannot flow as the [Water does] [therefore] the Upper surface of the frozen Earth [is] not [Equal] (as the Surface of the [Water is]) but full of Cracks [and] Crannyes, herby the little water in the puddle yet un-

frozen Sinks down into the Earth and there loseth itself, and this conjecture seams confirmed by the contrary Effect in a basen of Earth, or Pewter whose bottom cannot [be] so [opened], for there is never any hollowness under the Ice, but if the frost prevail the Water (made Ice) is all in a lump close home to the bottom. The force of [the Dilation] in [Ice] is great which Mr Boile in his discourse of cold demonstrates by Experiments of raising great weights [by freizing]. The Dissolution of Ice by warmth is the calling forth these fixing (yet volatile) particles of nitre, and thereby leaving the water to its natural fluidity.

In lower regions of the Air are found
Mist, Dew, Hoare, Ice, or frost upon the Ground

Chapter 16

Of Appea[r]ing Meteors

APPEARING meteors (so call'd, besides those reall ones before mentioned) are treated of by the Antients under this head but indeed they discerve not the name of meteors nor are bodyes at all, but certain shews which bodyes by the help of light do Exhibit.[1] [Of this kind are Numberd six.]

1. Chasm, or Gap in the heavens which is [either] lucid [or] dark.

1. Lucid [Chasm] is when [a] Luminous body is placed behind a stil cloud, thick in the Extreams, and thin, [or] parted in the middle, at which hole or Crevise the light breaking forth shows as if [the heavens] ware opened to discover the Glories [which are] above.

2. Dark [Chasm] is the Contrary when [a] dark spot is in the middle of a [bright] cloud, and then (as in painting) it shews like a deep well or pit as if a hole ware made through the [Skies] to look into the Abyss, both these may impose on a fearfull, and foolish fancy.

2. Halo is the hazy bright Circle about the [body] of the Sun, or Moon from a thin diffuced mist somwhat higher than Ordinary which when it condenses into Clouds soon after produces rain whereof the Halo is a Prognostick.

3. [Parelius,] 2 or 3 Suns [(as it were) appearing at once,] tis when a still thick watry Cloud is so placed by the side of the Sun, that the reflection of the Suns face (as in a [looking] Glass) fals directly on our Eye. [Hence] then are 2 suns the true one, and the apparent, but in case another such Cloud is conveniently scituated on the other side of the Sun, to take (like a 2d Glass) [the] reflection [of] the first reflection [and cast] that also to our Eyes then have we 3 suns; and so we might have more if these Glasses or Clouds were sufficiently disposed

4. Parasylene is the same in respect of the Moon

5. Rods, or brushes are the rayes of the sun breaking forth at the hole

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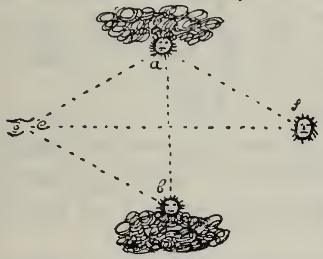
[1] Although haloes, parhelia, and paraselenae, as well as rainbows, are treated in the *Meteorologica*, they were particularly interesting to the seventeenth century. Boyle touches upon them in the *Experimental History of Colours*, which Morton cites; Descartes' considerable investigation of this branch of optics is echoed in Legrand, *Institutio Philosophiae*, Pt. VI, ch. XX, where may be found diagrams quite similar to the figures on the next page. Discussions of the same phenomena, somewhat unlike Morton's, may be found in the *Philosophical Transactions*, No. 13 (June 4, 1666), and No. 60 (June 20, 1670).

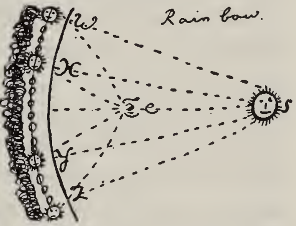
of a Cloud [sidewise] to our Eye, which if it ware directly towards us [it] would be the lucid Chasm before mentioned.

Appearing Meteors, Chasms the dark, the light,
Halo, more suns, or moons, rods, rainbow bright.

6. Rainbow [either Solar or Lunar.]

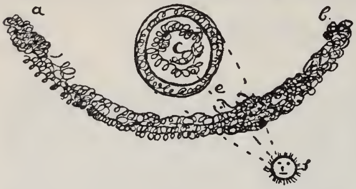
1. Solar that is the most notable of [all] these kinds as being dignifyed to become a seal of Gods covenant not again to distroy the World by water, this is of kin to parelius only the reflecting Cloud is [on] the other side of [our Eye] opposite to the [Suns body] the rainbow therefore is nothing but a multiplyed reflection of the Sun from a dewy Cloud, or [a] gently falling rain the Eye being placed in a direct line between the Suns body and the Center of the circle whereof the rainbow is a Segment. Compare the diagram[s] in the parelius (e) the Eye sees the suns body (s) by the line (e s) the Suns reflection by the cloud at (a) is seen by the line (a e) the 1st reflection (a) is cast over upon the other cloud at (b.) and from thence seen by the line (b.e). In the rainbow (s) the Sun, shines on the Cloud (W, X, Y, Z,) where the [ray] that goes to (W) by the line (S W) points there the Immage of the Sun and reflects it to the Eye (e) by the line (W.e) So that at (X) by (X e) that at (Y) by (Y e) that at (Z) by (Z e) and so on if there be never so many; for the suns lustre is reflected to the Eye only from those points of the Cloud [51] where the Angles of insidence and reflection are Equall, and though indeed the whole Cloud be Illustrated yet hence it follows



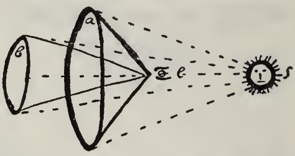


1. That we see not the rainbow as composed of many distinct Suns, (as it is in the pareleus and as it is expressed in the rainbow Diagram) because the rayes of the Sun are a multitude more than can be expressed by lines; and therefore only some few of them are set down, and the rest left to Imagination. Whereas indeed every little bubble or drop reflects the whole body of the Sun in little; the Multitude of which being Close set togather seam to be but on[e] entire reflection. In the parreleus the reflection to our Eye is but from one part of the Cloud, whereas in the rainbow tis from every part that on all sides stand at the Dew angles with our Eye; and therefore if the Earth ware transparent, we should see it a whole Circle,

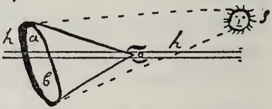
and not a bow. Once I well remember I have seen such an Entire Circle standing on a Convenient ground for the purpose. There was a Long deep valley that ran (E. and W) and a Dewy Shower was falling into the Valley, about a Mile off Eastwards from my Eye which was upon the ascent of the hill, [on] one side of the Valley; Here the Eye (e) being in the line between (S.) the Sun and (C.) the Center of the rainbow the hallowness of the Valley between [the hills] (a. and b.) gave me liberty to See the Lower part of the Circle as well as the upper part thereof.

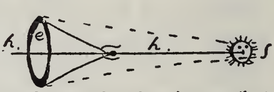


2. If the Cloud be nearer to the Eye the bow is [the] segment of a larger circle than when it is farther off; because it makes an obtuser angle in the Eye (According to the rules of Opticks) thus the Circle (a) makes a blunter Angle in the Eye (e) and there presents to it the biger object. Whereas the Circle (b.) being more remot makes a Sharper angle in the Eye and presents a less object thereunto.



3. If the Sun be high above the horizon (h h) then the bow will be a less Segment of the Circle (be [the Circle] Greater or less) because the Greater part of the bow-Circle (b.) is under the horizon (h.h.) therefore (a) the rainbow appearing is but a little above the horizon. But if (S) the Sun be near the horizon (as in the lower diagram) then the rainbow (e) is half the Circle, and therefore high above the horizon (h.) because the Centre of the Circle is [also] in or near the Horizon.





4. The Bow is still opposite to the Sun and therefore is never seen at high noon unless in winter when the Sun is low; then indeed a little [bit] of a rainbow may be seen in the north (Commonly Call'd the Dogs Eye in the N.) A Prognostick of cold stormy weather but where and when the Sun is vertical or drawing [near] thereto, (as tis in our summer dayes at noon) there can be no rainbow because all the Circle would be under [the] horizon.

5. If 2, or more of these bows appear the 2d is but the reflection of the first (as in the parrallius) and the 3d (more Languid) is the reflextion of the 2d etc: This appears by the Inversion of the Collours (according to the laws of Opticks) the Quite contrary way from that from which it was reflected.

6. The Collours of the Rainbow are purple, Red, Yellow, Green, blew, according to the variou[s] reflections, and refractions of light on the watry drops, the like we may See on the drops of dew; on a dimond; [or] a broad stream of falling water, where it has Some transparency of the light behind it, and Especiall[y] in the trigonal Glass from whence Mr Boile Illustrates the nature of Colours in his book on that Subject. Now that Colour of the Rainbow which is nearest the Centre and partakes more of light, or reflects it more fully to our Eye Gives the Suns Immage more red (purple or rutilous) that which is next to it may be conceived to be reflection from drops a little farther off; and Yellow is more languid than red; the utmost is blew which requires but a little light; and between the blew and Yellow is Green; which is a mixture of the blew and yellow, as we commonly see in a painters mixing of Colours.

7. The Prognostication of Rainbow is rain if it appears in the Evening; because the nights cold will farther condense the Clouds; but in the morning it foreshews a fair day because the dayes heat will rarifye the [Cloud] according to the old Saying.

A Rainbow in the Eve; put thine head in the Sheave,
A rainbow in the morrow; go take thy bow, and arrow.

Besides this natural signification it has also another instituted to as-[52] sure us of Gods Engagement, and purpose to moderate rain for the Use of man, and not to distroy again the Earth thereby. A Question is Usually put whether the bow were in nature before it was spoken [of] in (Genesis. 9.)? the Answer is Affirmative for the Natural cause of it was from the beginning. Therefore the Words (I Will put my bow in the Clouds) signifyes I will put it as a sign of my covenant, and not add a new creature to the nature of things.

Rainbow which dos no native beauty want,
Is more illustrious by Gods covenant.

2. The Lunar Rainbow is of the same nature and from like causes but with these differences.

1. The figure of it is a whole Circle about 15 or 16 Degrees from the moons body (Round about it) more or less according to the height of the Cloud.

2. The Cloud is between our Eye and the moon, [not] opposite as that of the Sun is; therefore it is nearer of kin to the parasalene, than the Suns rainbow is to the Parelius.

3. The Cloud is more thin and the moon shines pretty bright through it.

4. And therefore the Colours of it do scarce at all appear but only as a Whittish Circle somtimes edged with a pale purple; the natural pale Colour of the moon likewise contributing thereto.

5. The Prognosticks of this (as of the halo) is by the Colour; if more pale tis rain, If more redish tis a stormy wind; but if a more bright white; it commonly preceeds good wether.

Moon Circling rainbow doth pre[s]age we find
Wet weather pale; fair white; and reddish wind

And thus much of the bodyes call'd by the antients [imperfectly] mixt; namely meteors.

Chapter 17

Of Perfectly mixt bodyes, and first of Stone

A PERFECTLY mixt body is defin'd by the Antients, that which is constituted of a proper, Solid, and more durable temper of the Element.[1] That is when the site and figure of the particles, do contribute to their better adhæsion (as latter men explain it) its either Inanimate or Animate.

1. Inanimate is 3 fold, Stone, Metal, and Middle Mineral. These are distinguished by fusibility (or Me[l]tableness) or ductillity, (or Hammerableness) into shape; for mettall is fusile, and Ductile, Mineral fucile not ductile; but Stone is neither one, nor other, for fire burns it to Ashes; and a hammer brusses it to powder; and therefore 'tis the Opposite to mettal [in its Essentiall Qualities].

1. Stone may be defin'd Earthy parts firmly adhering togather, the Antients defined it a mixt body, Generated of dry Earthy Exhalation mixt with a Watry Clammyness, not dissolveable by heat or moisture. But this is lame of 2 legs; for 1st the matter seams to be more Solid than an Exhalation; and the Clamminess of water is but a weak Cement for so firm a body. Again the Water dissolves it not because its coldness contributes rather to the fixation of its parts; yet the heat of fire we see will do it; yea the Very fire-stones (so called because of their ability to [bear] fire long) will not alwayes hold out, as we see by the nead such furnaces have of repair; as in steell-mills, Glass-houses, etc: The Generation of Stone may therefore be thus better conceived; We will therefore Supose the first matter to be some fluor or Moisture in which is dissolved some Nitre of the Earth; This Solution by Quiet, Cold, and the [fixing] nature of Salt becomes hard; as we see salt doth Christallize in brine; or as Vitriol in its liquor; This Coagulation begun in one small place Chills the Adjoyning Earth already moistened with the like disposed fluor, and So that also accresces, and Sticks to the former, which (according to the naturall Inclination of all things) assimulates it to its self; and in the Work of Accresion, and assimulation it proceeds untill it finds no more such Imbibed Earth. In process of time the Saline and Earthy parts being well fixed the Watrey doth evaporate, and so the stone gets a sufficient hardness. But then the fixation, and Induresence drawing the parts closer

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[1] Legrand's treatment of stone (*Institutio Philosophiae,* Pt. VI, ch. ix) suggests that he and Morton drew upon similar Scholastic sources, but there are traces in this chapter of both Descartes and Boyle.

togather; in some place or Other the parts must Seperate; as in a floor Green laid, the boards being fastened must in their drying have their parts shrink togather, leaving Clefts, and Crannyes: so it is in this affair. And thus are made those clefts of the rocks, which are the Alembecks of fountains, (as is before noted) This Hypothisis (or Supposition) seams to be favoured by the Experience of some men; who carve, and Grave in stone; for these find the moist stones will cut, and shape better in the Quarry (while they are more soft and tough) than when they are hardened and made brittle, by being removed into the open air.

Stones Generation may be thus express'd
Fluor, Coagulate, and Earth accresc'd.

The Kinds of Stone, are precious, and Vulgar

1. Precious stones are such as are not common, but for their Vertues or beauty are far fetched, and dear bought.

1. Their Virtues Such as the magnet (of which before) the hematite or bloud stone, which stenches bloud not by Effluviums or steams (for then the Stone would wast) but by the passage of our bodyes steams through the pores of the stone, and returning again to the pores of the body whereby they bring with them either some peculiar degrees of motion or a certain stiptical or fixed tinge which cause the spirits to be sedate, and retire the bloud to coole, and coagulate or thicken, in the Orifice of its Issue, and So its flux to stop. The Viper stone from the Indies is said to cleave fast to the bitten place, till it Sucks out all its venome; and then falling off it must be laid in milk to draw the Venom again out of the stone or else the stone will break and be Spoilled. Irish slate good against bruises and clotted bloud. The Amythist [(says Pliny)][1] has its name from its power to prevent drunken-[53]ness; and diverse other stones have Virtues ascribed to them rather (I doubt) from fancy, than experience.

2. Their beauty which consists in transparency or Colour or hardness, or fineness of Gritt rendering them apt to polish. A Glossy pollish with good transparency gives the water of a Stone so much talked [of] by the Lapidaries

Stone price in Vertue and its beauty placed,
When with transparence, Colour, Gloss, tis graced

These Precious Stones are either, Smaller or Larger.

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[1] See *Historia Naturalis*, Bk. XXXVII, ch. lx. It is rather surprising that this is Morton's only mention of Pliny the Elder, whose famous book is comparable at many points with the *Compendium*.

1. Smaller fit for Gems, (as Diamond, Rubie, Topas, Jacinth, [Turcois] of the old, and New rock, Chrisolite etc:) The Origen of Gems (saith Mister Boile, as I remember on that Subject)[1] is a coagulation of a fluor in which is no mixture of [Gross] Earth, but only of Salts; first dissolved in water, and afterwards fixed again, and he thinks this may be suddainly done; as in the Christallization of Salt vitrioll, etc: (before mentioned) this I know that in Cornish tinworks lumps of pure Christal are found in the Caverns of the Rock, with which they have not the least Affinity; and in the Clefts also are found multitudes of Cornish Diamonds which are all Sex-angular, and pointed after one fassion, Shooting forth from a Stone of Quite another nature as if they had roots, and grew thereon. The Vallue of Gems (supposing their figures, waters, Colours, and Cleaness alike) is according to their magnitude or weight increasing still in Duplicate proportion: So that their weights are but the roots of their prises. This is asserted by Dr. Petty,[2] and is corrispondent enough with the practice of Jewellers; So that in their Estimation a Diamond of decuple weight is of Centuple vallue more than another; as if one Carret (a carret in stones is 3 Gold Graines) be worth 10*s* then a Stone of ten carrets is (not only worth 10 times 10*s* that is £[5] but) worth 100 times 10*s* that is £50 [yea, they say (as I remember) that after 10 carrets every carret is worth £5] as far as 15 carrets, thence onwards to 20 Carrets. One Carret is worth £10, and So onwards increasing the Value to 20, 30, 40, £50, etc: for one Carret added to a Great stone from whence we may see how a stone arises to such a prodigious value as £100000 which if it ware broken into 3, or 4, peices might not be valued at £20, and that the addition of one carret to a Great Stone may add to its value a £100 whereas the same addition to a small stone may not be worth 20*s*.

2. Larger precious Stones fit for use in buildings, as for Chimney peices, tables, etc: Such are marbles of diverse Colours, Agats, Alablaster, of which also is made plaister of Paris, the Italian stone, which represents Landscaps of trees, buildings, etc:

Of precious stones the worth you may conclude
From Water, Colour, Shape, and Magnitude.

2. Vulgar Stones such as are most common, and least valued, are Exotick, and Homebred.

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[1] Boyle's *The Origin and Virtue of Gems* (London, 1672), is again referred to in Chapter 20.

[2] Morton may allude to Petty's *A Dialogue of Diamonds* rather than to the *Discourse of Duplicate Proportion*. See *The Petty Papers*, edited by the Marquis of Lansdowne (London, 1927), II. 263.

1. Exotick, forreign, or remote procured for speciall uses such as the canestone for mils; the Norweigh-stone for Whetting, and Grinding tools, the hone from Italy, the Poliphant from Cornwall, the firestone, etc:

2. Domestick Hombred, or more common in many places which may be ranked into 2 Classes slates and lumps.

1. Slates that Split into thin plates, or lamines, or at least into even Surfaces; of these are two sorts in Cornwall, the blew and the Gray.

1. The fine blew Used for covering of houses, (not only at home but) sent abroad as far as London, France, Holland, etc: The best is deneboul-s[t]one of a Greenish blew, rings like Glass, and lyes on an house hundreds of years without rotting or mouldering. Those that are taken out of Clefts near the sea in some other places, (though they look as well to colour, yet they) prove very ill for use, for that they alwayes Sweat in [moyst] weather and soon rot the Laths.

2. The Gray slate that splits not so thin, and therefore is Used for building walls, the best is that which hath Good head, and bed, and not too many veines or Joynts in which they will be apt to crack. Besides these there is a rough [slate] of freet stone body Commonly Used for Covering about Oxford, and the Middle of England, where the sea doth not favour them with conveyance of better.

2. Lump stones that Split not thin but break any way; such are the Sparr, flint, freet stone, of all kinds the hard pebble, the Dunstone, some kinds of Marle, and Chalk, these 3 last are said to improve land and make it Good for Corn:[1] The Dunstone I know is a sign of Good land, and about bath many plowed lands are all covered with them; which sorts of lands they Call stone brash, light, that which hath small stones, and heavy that which hath Greater. In the tin country are two sorts of very hard [54] stone the one a dark and Blewish Rock; which as a Wall in many places incloses the tin. The other a Gray Spangled Stone, Called More-s[t]one Wonderfully Strong for building, and is Shaped handsomly by the peck: as freet stone by the Chyzall.

Stones Vulgar have their Use in all mens hands,
For Edging, building, fencing, bettering lands.

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[1] This information is of special interest because Morton's only contribution to the *Philosophical Transactions* (No. 113, April 26, 1675) was "The Improvement of Cornwall by Sea-sand, communicated by an Intelligent Gentleman well acquainted in those parts to Dr. Dan. Cox."

Chapter 18

Of Mettals, and Minerals

METTAL (they say) is a perfect Mixt body generated in the Veins of the Earth out of Sulphur (🜍) and Mercury (☿) or Quicksilver by vertue of the heavens and Elements, of this the properties, Finding, degrees, etc:[1]

1. The Properties are fusile, ([or] Meltable,) and Ductile, (or Malleable) from the former it can be cast, and [by] the latter beaten into shape; and they say the more mercury in a Mettal the more fusile it is: Hence it follows that tin hath most of it, because it melts Soonest; and this is made more probable by the agreement, and Suddain combination of tin, and (☿) in the Artifice of the looking-Glasses.

Sulphur, and Quicksilver so Mettals make
T'will Shape by hammering, and melting take

2. The finding of Mettals is with hazard, Difficulty, and Labour.

1. With Difficulty, to Know where it is, and how to Get it.

1. Where the Mine is, For this some have minded dreams, [as] if God did hereby reveal to them where to Spead. Some talk of the Rosi-Crucian Rod, [c]ut under some Constellations, and conjunctions of the planets. Some have noted the Collour of Sheeps teath; others the Sands of Rivers. But I think it were best to mind the peculiar plants, and Sorts of Stones, and Earths near the places; where the Mettals are already found; and of them, or of the Mineral Stones, or Oar (as its caled) to reserve parcels by one, as Examples.

2. How to get [at it], when we know where [it is]; This is difficult Somtimes by the hardness of the Rock (which fire, and water, or Vinegar opens as Hannibal was said to make his way through the Rock of the Alps); Somtimes depth in the Earth, Somtimes Springs of Water rising

[1] Perhaps because of his Cornish connections, Morton shared to an unusual degree in the widespread interest of his time in mines and mining. Boyle wrote some articles of inquiry touching mines, printed in the *Philosophical Transactions* (No. 19, November 19, 1666), which seem to be condensed in Morton's judgment on how to find "where the mine is." Other interesting parallels in the same journal are to be found in No. 5 (July 3, 1665), where adits and their use are described; No. 69 (March 25, 1671), in which there is a long account, with diagrams, of Cornish tin mines; and No. 137 (February 10, 1677/8), where Dr. Christopher Merret discusses the Godolphin Ball or mine in Cornwall, Cornish diamonds, "mundick," and other aspects of tin-working.

in the bottom of the work, which must be drawn out by Pumps, (Mill-Pumps the best) or let out by adits (that is new wayes cut from the bottome of an adjoyning valley into the Roots of the hill where the Mine lyes.)

2. Labour in Digging So deep; Drawing out So much rubish; making many Shafts only for Air, piercing those Adits; and then Most of the work is wett and Dirty, So that a Man can hardly Stand to it 3 or 4 hours.

3. Hazards, and that in Estats, and Lives; Of Estates by the Vastness of the Expence, and uncertainty of profit. £9000 hath been laid out in one Adit in a tin Work which proved worth nothing when all was done. Of Lives Somtimes by Damps, and falling in of the Country, though great Expenses and labour be [placed] to the Account of Security, [by] Sinking many Shafts or Airholes, and framing in much timber to support the Earth where it is any way loose or suspicious.

Mr Bushell (once servant to my Lord Bacon, and a Projecting man) offered to dig through the root of a mountain (Cal'd [Hingsondown]) in Cornwall; So as the Veins of tin should be discovered the rubish whealed out, and not Cleaned up, the Springs also dreined by the Same passage; and Supply the Want of Shaft[s] for Air in So high a Mountain by Great Bellowes wrought with a Water Wheel the Wind conveighed in by artificiall pipes made fore the same purpose. An odd conceited proposal, Not Sufficiently understood by the Country to Encourrage them to adventure So much mony as was required to do it. Though to an Old proverb tis said

> If [Hingsondown] ware well a Wrought
> t'ware worth London-town dear a bought

However the thing well considered may have Somthing material in it.[1]

3. The Degrees or Kinds of Mettals (for Men are not well agreed whether to call them degrees or Kinds) The Chymists say that all mettals are Speciffically the Same, only there are two great principles of consti-

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[1] The proverb quoted by Morton may be found in almost any book on Cornwall. See, for instance, Gilbert Davies, *The Parochial History of Cornwall*, I. 152; S. P. B. Mais, *The Cornish Riviera* (3d ed., London, 1934), p. 19. Thomas Bushell's proposal was but one of many projects for Hingston Down, and but one of many schemes by that energetic mining man. Mr. Morison has indicated the recent study by J. W. Gough, *The Superlative Prodigall, A Life of Thomas Bushell* (London, 1932). But Bushell's bellows were not new in principle; they and other of the methods noticed by Morton may be studied in Georgius Agricola, *De Re Metallica* (Basel, 1556), a famous book translated, with notes, by Herbert Clark Hoover and Lou Henry Hoover (London, 1912). The Hoovers have many suggestions for a reader of Morton; they describe, for instance, the vast literature on Hannibal's supposed use of vinegar to split the rocks of the Alps. It is worth noting, too, that bellows were actually used at St. Agnes in Cornwall in 1696, before Morton's death. See *The Victoria History of the County of Cornwall*, I. 546.

tution (🜍) which hath more of Earth, and (☿) more congenial to water, and according to the Various Combynations of these in Quantity and Quality, and their different purity, and Concretion, give the Various differences which we call the Kinds of Mettal.

Primary Mettals are accounted Six; Gold, Silver, tin Lead, Copper, Iron. [55]

1. Gold whose Chymical name is Sol, and Mark (☉) is Said to be of most pure, and best prepared Materials, hence it hath many Attributes, that transcend other Mettals, as Value, Weight, Duration, Ductility, Attraction, Medicinall Use, etc:

1. Value, £3 Sterling per oz; More If Perfectly fine. The finess is Estimated by Carrets; a Carret is $\frac{1}{24}$ of one oz. [If Gold in the refiners fire lose nothing of] its Weight tis said to be 24 carrets fine (or Pure Gold) but if it be alleyed with baser mettal, (such as Silver, Copper, etc:) it looseth in Such fire some of its weight, by burning off Such baser mettal; Hence alleyed Gold, is 23, [22, 21], carrets fine according to the Loss in refining [of] 1, 2, or 3 Carrets; [the Allowed Alloy for Sterling Gold is ½ gr. so that the Metall is Reduced to the] finess of 23 Carrets 3 Gr. ½ ere it be accounted Sterling (or Standard) and therefore ere it be coyned for Mony, (Namly Angel-Gold, for Crown-Gold hath more alloy i.e. 22 Carrets fine will serve)[1] or Ere it be tower touched, for Sale in vessels, that is marked with a stamp of Authorized to Judge of the true value.

2. Weight, the Greatest (for the bulk) of any Mettals for being compared to water the difference will [appear]
Gold is as 18½ to 1.
Mercury 14 to 1.
Lead 13⅗ to 1.

10,000 Sterling is Cal'd a tun of Gold.

3. Duration is supposed perpetual, when in Scripture tis cal'd Corruptible ([as] 1 Corinthians. [9], 25. 1 Peter. 1, 18.) tis not Said in respect of its nature, but our possession thereof. It never rusts, nor consumes with often melting (7 times a definite number put for an Indefinite, Psalms: 12, 6,) tis only purified, but not consumed; tis indeed dissolveable by Aqua-regis (Æ) and that only; but then tis only broke into small parts; for this dust precipitated (i.e. cast to the bottome of the Liquor) and collected may be again melted into a mass of the same weight, and vallue, ☿ will Change its colour and make it brittle, but that is soon recovered again by the fire.

4. Ductility or Extendableness beyond all, It may be beaten or stretched

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[1] For the value of gold and its place in English coinage, see A. E. Feaveryear, *The Pound Sterling*, pp. 71–90.

admirably thin; one Grain of Gold, beaten into leaves, will cover (as I remember) a yard square. And a Silver Ingett of 3 Inches gilt, will stretch in [wire many hundred yards,] and be all over gilt all the way. An Inch of [the] Wire may be divided into an 100 sensible parts (as is shewn in Geometry) and If the Wire be Superfine (as they call it) that is as small as a mans hair; one such hundredth part of the silver must be a verry small Quantity, but how much less must be the Gold that covers it

5. Attraction of Mercuriall, and Arsenick steams in a Wonderful manner for If one holds Gold in his mouth, and touch mercury with his finger or Toe the Gold (tis Said) will be seen [turned] white (but I would [in no wise] wish any body to be too bold in such Experiments least by drawing the mercuriall steams through the body they Get a Palsey.) I have seen a Gold ring tinged and broken (upon a fall to the Ground) by holding it a few minutes over a bladder of Mercury. Also I Know one that dayly Swallowed Pellets of Gold, (as Pills) to Extract the Mischeif done by Mercurial Medicines which dayly tinged the pellets even 5 years (and how much longer I Know not) after the mercury had been taken. Add to this what was Said of Dr Butler that he convinced Dr Moiheron that Prince Henry had been poisoned by putting a peice of gold in the corps mouth, and after a while taking it out tinged white,[1] and hence perhaps 'tis said to have

6. Medicinal Virtue as a cordial; Pills are Guilt (not only to take off the [druggie] tast, but) to draw venemous steams from the principle parts to the bowels, where mingled with the Medicine [they] are carryed off therewith; I Know not how else it should be cordial, for Certainly no heat of mans stomack can digest it. besides this of attraction there is another way it helps by repercussion as of Scrop[h]ulus Tumours commonly called the Kings Evill (from the [fancy] that his touch doth Good) for it repells, and Dissipates the humours or Checks them from flowing faster than nature can subdue them, but this is no such Excellency, but lead partakes of the same

7. The place of Gold is where it is found; In Barbary tis found in the Sand washed off from the Mountains into the Rivers, but in the S.W. Parts of America tis Digged out of mines by the Spaniards Slaves. The Alchymists will tell you [that] tis the Soul of every mettall found where

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[1] Morton here repeats a popular, and probably erroneous, story about the death of Henry Frederick, Prince of Wales, in 1612. See the articles in the *Dictionary of National Biography* on Henry, William Butler (1535–1618), the royal physician, and Sir Theodore Turquet de Mayerne (1573–1655). There is also a pamphlet by Sir Norman Moore, *On the Illness and Death of Henry Prince of Wales*, which demonstrates that the prince died of typhoid fever.

ever any mettall is, and that [it] is Extractable in small Quantity from each of them, they call [it] the Soul, and life of the Mettall, because when this is Seperated all the rest of the Mettal is brittle and drossy, and Good for nothing. [56]

There [is] a Story of a Dutch Skipper who Walking with Mr Godolphin[1] to see his blowing house for tin, and Seeing a Goodly Quantity [melted] in the trough [having] its Glorious Golden surface (as is Usuall) Asked the Workmen merryly what he should Give them for so much tin as he could take out Sticking to his rod? They answered him what he pleased: He therefore bathing his rod several times in the fluid tin, alwayes wip't off, and put into his pocket the little thin scales that Stuck to it; and So departed; After 5 Years he again visited Mr Godolphin, and gave him a Gold-ring with Mr Godolphins arms upon it affirming that it was the same mettal that he had taken up with his rod. Upon this was cal'd to Mind that the same block of tin was Spoiled, and brake all to peices when it came to the Coynage, and that the tinners had Said that the Dutchman had Conjured, or poisoned it with [his] rod.

8. The Artifice of Gold by Alchymy came from the last consideration, [for] hence they took a Great Confidence of a transmutation of all mettals into Gold, by curing the Leprosities of them (as they Speak). This opperation is cal'd the finding of the Phylosophers stone; and tis affirm'd, that Some have done it, such are cal'd the Adepti; Sons of Art, Sons of Hermes, etc: Of this Number are Eminent Raimundus Lulius, who in the Dayes of our Henry 7th made (tis said) that Excellent Gold of which Rose-nobles ar[e] coyned. Yea Some say that afterward he Communicated the [noble] art to the Senate of Venice, and that they Exersise the Art (at this day) in their St. Marks Tower from whence come forth Continually unaccountable Quantityes of Gold, besides Lullius ware famous Paracelsus, Vanhelmont, and others of whom we shall not farther Insist.

9. The tests (or trials) whereby the reallity and [fineness] of Gold is discovered (Differing it from what is counterfeit, and Debased) are the [Load]-stone moved over or near the Gold; Sand Sold in Barbary by the Jews for thereby is seen if any fillings of Iron are Mingled amongst it. Also when melted down the refiners fire the touchstone weighing against brass in Water, and especially the Aqua Regis (Æ)

Pure Golds Weight worth, lasting Ductility
Attraction, Cordial, Place, art, what will try

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[1] This story probably refers to Sir Francis Godolphin, who some time in the sixteenth century imported a Dutch mining expert to show him how to improve mining methods in the famous Godolphin Ball. See *The Victoria History of the County of Cornwall*, I. 548.

2. Silver is the Second Mettal, and next in degree to Gold; This hath its name in Chymistry, (Luna,) and Mark (☽.) It has many Qualities like Gold in an Inferior degree. As its alley for Sterlin[g], by penny weights, (one penny weight is in value 3*d* [and then it is worth 5*s* per oz.]) Its weight in the same bulk is much less than that of Gold; twill beat thin but not as Gold, and Stretch its Wire beyond any Mettal, even in smallness beyond a Mans hair; which wire they call super fine (as is before noted) It rusts not but Cankers a little into a Pale blew, Consumes Somthing (but not much) in Melting; because its parts are of less compactness and weight, and so may Volatize away.

'Tis Dissolvable (as all [other] Mettals Except Gold) in Aqua fortis (ÆF.) and a thin plate of it (as a [Groat], or thinner) rubed with brimstone, and held over a Candle, splits, and Moulders, because tis calcined; the powder of which paints Glass Yellow. It Cheifly comes from the West Indies, and high Germany diged out of Mines in an Oar not much unlike that of lead, or Antimony, and tis said that richer veines of lead have much of Silver in them. When the Oar lyes open to the Air it Somtimes sends fort[h] branches (like White Moss) of pure Silver, cal'd the Silver tree which is said to be Immitated by Some Chymists; who also pretend [to make factitious] real Silver by a Lower preparation of their phylosophers stone. Besides [which] there is a Counterfeit of it by blanching (i.e. by Whittning) Copper too well known by the knaves [who] Cheat by false Plate, or Mony. Its common tests, are the touchstone, and the fire, a vessell of it in Common Use is long [in] heating but then it holds heat long.

Golds Quallities are silvers in degree
Peculiar[s] are it[s] Wire, and Silver tree.

3. Tin its Chymical name is Jupiter marked thus (♃) is a fine Wite Mettal near the Colour of Silver. Tis the lightest of all mettals, and Soonest apt to Melt, (therefore fit for Solder) and of its self more brittle than any, and therefore tis mixed with lead, and Somtimes brass in Making of Pewter, but a greater Mixture, or brass, and Antimony Makes bell-mettal. It alone overlayes Iron plates to make lattin (or laid tin) which plates are hence called Vulgarly by its name tin. It foliates well, and the leafe thereof spread on the [glass] plate, and concorporated with (☿) cast upon them (which it presently doth) by pressing them close togather are made looking Glasses. Tis found Cheifly in Cornwall, and before Queen Mary's dayes only [there] in the known parts of the world, but then persecution driving away tinners, they found it allso in Bohemia. However

it is yet a con-[57]siderable Staple to the [County] of Cornwall, and indeed to all England whose Merchants conveigh it away in Great Quantities, Especially to the Streights For Turkey. The Antient Phœnitians were wont to fetch it from hence yea, and to digg it with brazen Instruments some of which are found somtimes in our old tin works, and Some hence derive the name of Brittain which (say they) was given to this Island by the Phœnicians, in whose, and the Hebrew language, brittanack (the Name that they called us by) signifies the Land of tin. Its Value is various, and hath fallen in less than 20 years, from 6[£] to less than 3[£] per cwt: Yet the Præemption (or first buying) is accounted worth to the King £12000 per Annum. There is a Kind of tin in the East Indies called Tutenag, but wether it be natural, or factious of Silver, and tin, is a Quære.

[Cornish Tinn Brittains name did give, it passes
For Solder, Lattin, pewter, looking Glasses.]

4. Lead, Chymists call it Saturn Marked (♄) a common Mettal in many parts here in England; tis Especially found in Darbyshere, and [at Mendip in] Somersetshere; tis more heavy than any other Mettal, or Minerall except (☉) and (☿); and therefore its Used in bullets; Tis tough, and flexible above others yet not Extendible into Wire, as Silver, steal, and brass; It is allso Medicinally Used (as Gold) to repell humours, Beaten into thin plates, and [I] suppose a little Mercuriated on the one side; and because of this agreement with Gold in Weight, and Medicinall Use; tis supposed by some the fittest mettall for transmutation. The Canker of lead by Vinegar, is called Coruse; the flower, or Calcination is Wite-lead; this hig[h]er burnt makes red-lead, or Minium and these are Much used in plaisters, boiled up with Oil, bees-wax, Turpentine, etc: the price is small, about 6, or 7*d* per lb: It is therefore applyed to many common Uses, as Cisterns, and Pipes for Water, Covering of roofs of Houses, and of late Sheathing of Ships, for long Southern voyages; mixing [with] tin [in] Pewter, and that [many times too much] because of its Cheapness

Lead is a Common thing, to health conduces
for Pewter, Roofs, Pipes, Cisterns, other Uses.

5. Copper its Chymical name is venus, Marked thus (♀) its a very Usfull mettal, next in Value to Silver, about 1*s* 2*d* per lb: tis Cheifly found in the NE. Parts of Europe, about the Sound, (or baltick sea) where being plentifull tis Used (as we Use lead) for Pipes, and for Covering of houses, but in remoter parts for Vessels, Great boylers, furnaces, Kettles, Cups,

Boxes, etc: yea tis coyned for small mony, in most parts of Europe, and because Silver, and Gold are more scarce in No[r]thern Countryes where Copper is plentifull, there Copper plates are the Computation of their riches, and pass in bartar instead of Monyes So that a bargain is satisfyed therewith, and a Maids portion is carryed home in Carts; Copper being blanched (as they Call it) immitates Silver; and being artificially Mingled with Caliminary stones makes brass; hence the Nautious tasts, and Vomitive power of Liquors that stand in that compounded Mettall. Its Canker or Verdigreace is of Good Cleansing power in outward applications to putrid Sores. Brass also is of a beautifull Golden colour, Makes Usefull and Comly [houshold] stuff; and Works Smooth Close, and Clean, for Stopcocks, Mathematical instruments, yea, and the finest Engines, [such as] Clocks, [and Watches. Compositions of Brass, Tinn, Iron and Antimony, make] Belmettall. Lastly Copper though its Colour be a reddish [y]ellow yet its tincture is blew, as is seen in the Chymicall opperations thereof. In its vitriol, (Caled the Roman Vitrioll,) the Great Material of the hopliatricum (i.e. Weapon Salve [or Sympathetick powder]) and in its Calx Used in the painting of Glass.

Copper makes Vessels doth for mony pass
Mixed makes bells, and Comly Usfull brass
The Weapon salve, and the blew Paint of Glass

6. Iron Cal'd Mars marked thus (♂) the Most common Usfull, and Necessary of all Metalls; because all tools for work conducing to the life, and Comfort of Man are [framed] hereof. Its hardness renders it fitt to make or hold, an Edge or Point: Now as line and point in Mathematicks are Apt to divide [quantities]; So these being but Solid and firm line, and point divide Physical bodyes the Subjects of Quantity. The Necessity of it further appears In those inventions of men [that] have wanted it, to supply [its] defect by a Sharp flint, a Fish-bone, etc: Amongst the Amerricans[1] and Affricans unto this day [they] barter Gold for it allmost to even weight, Yea to Show their Esteem, and preferment thereof they wear it for Ornament as we do Golden Chains, about their necks and Arms. Among the Oar of Iron [is] found the Admirable Magnet, which is So Congeniall to this Metall that it draws it to its [58] self, and directs it to the North a Mystery of Nature, not only of admirable Use in Navigation, but of that subtilety, and Sublimity as deserves to be contemplated beyond

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[1] Morton means here the American Indians. The first instance of "American" meaning a "native or citizen of the United States, or the earlier British colonies included in these" is, according to the *Dictionary of American English,* in the introduction to Cotton Mather's *Magnalia* (1702).

any thing in Gold, or any other pretious terrene body. So [that] next to the light of the heavens, and the Alamentary Surface of the Earth we may well say blessed be God for Iron; to which the King himself is more [beholden] than to all [his] treasures Else. Iron when first Melted runs into Moulds, and makes Vessells, Guns, Chimney-backs, balconies, etc: but afterwards being hammered becomes more tough, and Elastick, or Springy; Especial[ly] Steal which is but Iron further heated, and beaten. If Iron be beaten into thin plates, and washed over with tin tis cal'd lattin, (as is before noted) and with brimstone t'will melt, and calcine for Medicine, or the Tincture of Glass black. Now to all these Excellences add that it is of small Value (1*d* per lb:) because of its plentifulness in most countryes. So good is God to Give most of the best things.

God gives us Iron, the most Usfull thing,
Its Edge, Point, Magnet, Calx, plate, Steal, and Spring.

And thus of Mettalls properties, Finding, degrees, or Kinds, and now at last of its

4. Composition of diverse of these Simples, either with pure mettal, (as lead, and tin [for] Pewter) or with some mineral, (as [copper with] Lapis Caliminaris for brass) Iron or Any other Mettal (Except lead) with antimony for bell metall. There may be many other Mixtures for various Uses, as mens occasions require, and the Artist please: So in Spelter, [Alchymy], Metalline Speculums, [printing] letters, etc: of [all] which Mixtures this is to be noted, that Mixture makes it hard, Stiff, brittle, and apt to Vibrate, or ring; and what is thus composed by the founders may again be analized, and resolved by the refiners.

Of Metalls, propertyes, and how to find,
Know its Degrees, or [Kinds], and how combin'd

And So Much for Metalls, after which, and Stone, follows

[3.] Middle Minerals which are neither fully Stone nor Metall but partake somthing of both, and being Generally Fusile, not Ductile, Such as Salt, Sulphur, (☿) and its Arsenick fossile, Alume, Antimony, Marcassi[t]e, or mundick, and its Vitriol extracted from it by art, Tin Glass, Calony, or Lapis Caliminaris, etc: All which are a Sort of Imperfect Metall or Mineral juyces, contributing to the constitution of Mettalls; and [where] they [are they] doe Generally Infect the Springs of Water rendering them heavy, rough, Acid purgative, etc:

Minerals imperfect Metalls, are; Earth juices
turn fountain Water into Medic-Uses.

Chapter 19

Of Animate bodyes in Generall and Speciall {*Vegitable* / *Sensible*

ANIMATE bodyes in Generall are defin'd a perfectly Mixt body consisting of an Organicall, (or Instrumental) body (as the Matter) and A Soul (as the form) of these two Physical parts.[1]

1. Organical (or Instrumental) body is that which is furnished with fitt Instruments to Exert Vitall Action such as are after Described [under] the Generall names {
Vegitation
Sensation,
Raciocination.

2. The Soul Useth to be defin'd the first act of a Physical Organical body, having life in power; which definition is obscure enough. Wee may rather call it the Inward, and Immediate Principle of those actions which are commonly Known by the name of Vitall.

The Affections of Animate bodys in General are either {Primary, or
Secondary.

1. Primary, Life; the Continuation of Union of the Soul in, and with its body; Death is the breach of [that] Union, and Dissolution of [the] Soul from [its] body.

2. Secondary, Health; a perfect disposition of the Animate body, whereby its fit to Exert all its Vital Opperations. Desease, and Sickness, is an indisposition of the body for such opperations.

The Species of livers are {[Vegitative] or
Sensible, which are {Brutal, or
Rationall.

1. Vegitable, (purely So) is plant consisting of an Organicall body, (whose parts are root, Stalk, branches, etc:) and a Vegitable Soul (whose faculties are 3 Nourrishing, Growing, and procreation.)

1. The Nourishing (or Nutritive) power is that whereby it is able to convert Aliment into its own Substance, Its act is nutrition a kind of partiall Generation for it partially Introduceth its own form in the matter

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[1] From this point on through Chapter 30, Aristotle's *De Anima* shapes the general outline of the discussion. Evidently, however, Morton was familiar with the anatomical and physiological notions of his own time, as they were summarized in medical books designed for the general public. Comparison with Legrand and with the "Digression of Anatomy" in Burton's *Anatomy of Melancholy* shows how much Morton's knowledge of the nutritive process, procreation, and the processes of sensation was common property.

of the Aliment, for this is required that the Aliment be somewhat like, and unlike. [59]

1. Somwhat like; Else the Constitution of the liver would abhorr it, and therefore a man cannot live upon Stones, Iron, etc:

2. Yet Somwhat Unlike; Else the [living creature] cannot concoct it; for there can be no action, and Reaction upon things alltogather alike. Hence a Man cannot digest mans-flesh; Raw-flesh; Some say Horse-flesh, because these fleshes are too near the nature of his own. Also Dogs, and Cats, and all Carnivorous birds, and beasts of Prey; because they feed too near the feeding of Man. Yet In Necessities of Fammin these things are Eaten, and then they alter them by Salt or Smoak (Called Barbicuing) Or perhaps the bodyes of men are altered by fasting to put them at a Sufficient Distance [for] their food; But If not then the Ill Digestion causeth Sickness; The Plague being an Ordinary comcomitant, Of famine because of foul feeding.

3. And from hence the rule is that Aliment must nourish, and not alter the body for this distinguisheth it from Medicament whose property is to alter and not nourish.

Like, and Unlike, must be for nourishment
Of Medicine to alter is the Intent.

N.B. To this Nutritive Power are Subservient, the Powers Concocting, or Digesting, and what are Subordinate thereunto. Concocting is the Power of Assimulating the Nutriment more and more to the [Substance of the] Nourished. Its action is Concoction commonly distinguis[h]ed into an order of 3. The 1st, 2d, and 3d Concoction whose Acts and [order] are not So manifest in plants because of the [Defect] of Organs we shall therefore treat of it as it is manifestly found in Animalls Allowing to plants Somthing Analogous thereunto.

1. The first concoction is Chylification (or turning the Aliment into Chyle) this work is done in the Stomack, preparitory whereunto are dressing by roasting, boyling, or baking. And after Mastication, (or Chewing) Moistening [it] with the Spittle (that Great natural menstruum) and Swallowing which cannot be done unless the tast be Sufficiently pleased, to intimate to the Stomack that it is convenient for it. This it does by reason that the pallat, and Stomack are both of the same continued Membrane. This [Prelibation], and foretast in beasts lyes more in the Smell, and therefore they Smell to Every thing before they tast it with their mouths; the rather because a thing disliked in their mouths cannot be spit out for the roughness of their tongues. When in this order the Ali-

ment is received into the Stomack, it is Soon turned into Chyle, which is a Mass of Meat, and drink macerated and Altered all into one [similar] Substance, (not much unlike batter) as may be seen in dissection, or Vomit 2 or 3 hours after meat. The Great Question is how it is thus Subacted, and made? The Answer is that the Preperation (before noted) being supposed, the Stomack retains in its self a certain fermenting, Dissolving, and Corroding, Juice, (or Menstruum) which being put in more vigorous action by the heat of the Stomack shrinking Close to the Meat, does open the Small parts thereof, and Make them fitt to mingle, and then the Said contraction dos also Chrush them one among another. To help the Stomack herein Sawces are prepared, either such as are warm to increase the heat, or Acids to Sharpen the fermenting juyce.

Chew, tast, and Swallow food, and in a While
The Stomack heat, and ferment make it Chile

But a Greater difficulty is whence hath the Stomack this dissolving menstruum? The Antients thought it was from the Capsulæ Atrabilariæ (2 Grandules that arise from the emulgent Veines near the kidneys) but Anatomists find no such Acid Juice in them, nor a way how to convey it from them into the Stomack. Others have thought it is [rather] some remainders of the last Chyle reposited as a leaven between the wrinkles of the Stomack which is rough within, thus an Irish bonny Clauber pot being never washed by the remainders of Sower milk that sticks to the Sides presently Sowers, and Curdles any other milk that is put into it. Dr. Charleton[1] will have it to be acid flegm seperated from the blood in its Circulation, by that branch of the Cœliac Artery which comes to the Stomack; now the Mass of blood being an Aggregate of many Juices, deposites them severally into divers places according as the pores of one or other part are suited to the Magnitude or figure of the particles, which are constituents of this or that liquor; So the Liver Seperates Gall the Kidneys Urine, the Grandules of the head Incipid flegm (or Spittle) and So [60] the Coates of the Stomack being full of Such little Grandules draw out this Acid Juice of which we speake. This Seperation (saith Dr Cole in his Animall Secretion)[2] is Effected by the brisk Motion of the nervous liquor, Cross the Course of the blood, whereby it stricks out those particles that have adjacent pores fitted to receive them, and so this Active liquor passes in part with them, the rest go on with the blood augmenting its vivacity; so that according to this hypothicis, the Chylyfick ferment of the Stomack, is a Compound of the residue of the blood, and the Active Nervous liquor heightened to the best natural state by convenient causes, and sometimes (on Occasion) lifted above the natural state by medicines, when there is no food left for [this] Acid to feed upon; it Velicates the Coates of the Stomack it self, the pain, and perception whereof we call hunger, or Appetite, which by a metonimy of the Effect makes Good the proverb (hunger is the best sawce) because the Natural ferment, if it be ready for your food, (which [is] intimated to you by your hunger) is better than any artificiall which you can provide.

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[1] Walter Charleton (1619–1707) was author of *Natural History of Nutrition* (London, 1659).

[2] William Cole (1635–1716) published his *De Secretione Animali* at Oxford in 1674.

Better the Stomacks ferment naturall,
than any which is artificiall.

That all men have not Equally Digesting Stomacks nor the same men at all times; tis partly from the Quantity, [and] Quality, of this Acid ferment; partly from the food more or less digestible, partly from the tone of the Stomack, which if it be flaccid, and cannot contract it self Vigorously the digestion is weak; upon any of these accounts the meat either lyes, and putrifies whence follows looseness, or some deseases, or else it passes away unprepared to yeald out its [benign] Juice for the nourishment of the body, hence it follows that it is not much or Good meat, but Convenient Quantity seasonably taken, and well digested, make fat and vigorous. Tis observed in feeding hogs that when they too much raven their food, barley, and Oates will come through them so Intire, [as to] do them but little Good; and then other hoggs, and poultery will feed upon it. Tis also observed that for feeding hoggs which are shut up and cannot walk to preserve the Stomack, cleare water is better for drink than fatt wash; and that it is good somtimes to let them run abroad. The like is practiced in feeding Geese, for if once their bills Grow pale they will never feed unless they walk, all this is said to shew how considerable it is to hold up the Stomack, and its ferment in Good plight; and indeed the work of Chylification, is of so great concernment, as that the Stomack doing its office Ill, Herein is said to be the Shop or mine of deseases, because (say Physitions) an Error in the first concoction cannot be corrected in the 2d and [Bad] Chyle yeilds bad Chyme, bad blood, Spirits, [bad] humours, etc: Conducent to Good concoction are somtimes medicine somtimes fasting, to carry off unconcocted food, and Insiped flegm; but, Ordinarily Convenien[t] Exercise Digestible food, and that well drest, and eaten in Moderate Quantity; Also very considerable is the due mastication (or Chewing before mentioned) of which I shall give 2 or 3 Instances.

1. The first is lobsters which (either because they want a Sufficiency of the Acid ferment, or that their mouths are not shaped conveniently to Chew) have by nature given to them teeth in the Stomack (commonly called the lady in the lobster) for the due grinding, and cominution of their food.

2. Another instance is in ruminating beasts who having [Swallowed] their food too Intire return it again out of their Paunch into their mouths, where they work it over afresh in Chewing the Cud.

3. Lastly fernelius[1] reports that Zachutus Lusitanus when he was an Old man found at Padua a Woman of his own Age, that was fresh, and fair, as if young; only by the Constant Use of Spirits of Sulphur or Vitrioll mingled with Water to preserve the teeth; which at a Great age were all Intire, and thus much of the first Concoction.

Chew well Good food what's hungry Eaten pleases
and Profits; bad digestion [feeds] deseases.

2. The 2d Concoction is Chymification, (or the making of Chyme); this was antiently supposed to be in the Meseraick veines; but that is a mistake, and indeed it is not made at all by any Concoction, but only by Seperation and that in this order. When the Stomack has made any part of food into Chyle, tis by the Contraction thereof thrust out into the Guts The first receiver is the Duodenum where it has a mixture of Gall from the Gall bladder in the hollow part of the liver; this contributes to it a further preperation, and renders it more fitt to have its Sweet, and [Alimentary] parts seperated from [those] that are Useless; for the Gall by its fatty Smoothness, makes the Guts Glabrous, and the [feces] slippery, for their better discharge; and yet by its Acrimony is pungent to the Guts, and Stimulates their peristaltick motion; (a motion in the Coates **[61]** of the Guts, much like that in the body of a creeping snail or Earth worm) and hereby at once they Chrush the [feces] downwards, and the Usfull Chyme into the lacteall Veines, The Liquor in these Vessels is at least like milk, if [it] be not perfectly the same; the Lactealls are Certain small conducts Quite distinct from the Multitude[s] of Arteryes, and veines disperced throughout the mesentery [yet are everywhere amongst them, and conveigh the Chyme in a common Receptacle, scituate at the Roots of the mesentery,] whose place is above, and near the Vertabras of the loines (that is those parts of the back-bone next under the ribs). Hence by two Channells or Streight pipes (Called Ductus Chiliferi) tis carried up by the

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[1] Jean Fernel (1497–1558) was a prolific medical writer, whose works were long popular throughout Europe. Where he relates this story the editor has not discovered.

back-bone to the Subclavial branches of the Venacava, (or those parts of the Great hallow vein which are under the Collar-bones) and near the External Jugulars (or the Great neck-veins) Its intermingled with the blood; and through the Upper trunck of the hollow vein is carried in the right ventricle of the heart. This passage of the Milkey liquor from all parts of the Guts except the rectum (that is about a foot of Gut at the lower end) into the heart is called Galaxia, in allusion to the Milkey way that [we see] in the heavens, and here Ends that which [is called] the 2d Concoction.

3. The 3d Concoction is Sanguification or turning the Chime into blood, and onwards into compleat nourishment of the body. The liver was antiently supposed the shop of blood, and that thither only the Chime was carryed to be perfected; but Since the Circulation was found out (by Dr. Harvey about 60 or 70 Years since)[1] the Vogue is that blood makes blood by assimulation, for in running the rounds with it, and the blood acting all along upon [it by] its Vitall Spirit (being 10 times as much in Quantity, and 100 times [more] in Vertue) it must needs Subdue the Chyme, and conform it to its own likeness. The Circulation of the blood (whereby this act of Nutrition is performed) may be thus Explained. The vessells of the body Containing blood, are the Arteryes and veines. The Arteries carry forth the blood hot, and vivacious from the heart to the Several parts in Every pulse; This from the Ends of the Small Capilary branches is thrust out into the flesh or Substance of Every Member, Then being percolated thro the flesh, and having left there what is fitt, and Sufficient for Nourishment it is received into the Capilary branches of the veines [passed] on by the Greater branches, and by them again is conveyed into the heart; there to receive a new Vigour. So then the Chile (or Chime) being mingled with the blood in the right Ventricle of the heart (where we last left it) it proceeds with the very next pulse (or Systole, or Contraction) of the heart through the artereous veines; into the lungs, there it is attempered with the Air of our breathing; thence it returns by the Veinous Artery into the left ventricle of the heart thence tis pressed forth into the Great Artery thence Several wayes for the Depuration, or nourishment: for Depuration into the Stomack to deposite acid humours; to the Guts, to leave there Insipid flegm, to the Kidneys for Urine; to the Liver for Gall; to diverse Grandules for Spittle, tears, [Sweat], etc: and for Nourishment to every part of the body, Externall and Internall always returning to the heart by veins which every where in due proportion do accompany the Arteryes. The Circulation in an In-

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[1] Morton's acquaintance with Harvey may have been directly through the *De Motu Cordis et Sanguinis*, or through some intermediate source. See the note on p. 193, below.

fant Unborn is somwhat otherwise; for the Mothers blood filling the placenta (or Secondine) Vessel[s] it passes thence by the Navell Vein, into the Childs liver; thence by the Vena Cava (or hallow Vein) [to] the right Ventricle of the heart, thence (not to the lungs because as yet there is no [respiration] or breathing,) but by the artereous veins and a peculiar [passage] into the Aorta, and the left ventricle of the heart, thence into the great Artery, whereby it is disperced over the body sufficient for its nourishment, but the Greatest Quantity Goes forth, by the Navel Artery; and thence returns as before.

The Quantity of blood in an healthfull, and well Grown man is between 15 and 24 lb All which passes through the heart between ¼ of an hour, and 2 hours. The Quantity of blood passing in every pulse, or beat through the heart is from 1 oz. to 2 oz. the Number of pulse in an hour is from 5000 to 2000 for so much do authors differ in their Oppinions thereof. In Men that drink, [and] Urinate much some have fancied there must be a shorter way for the Liquor to pass than in this Circulation but tis said that no such wayes are found by Anatomists; and that those mentioned are sufficien[t] because the assumed liquor in such Quantity Continues not Circulating with the blood as the [62] Chile does; it is therefore not mingled with the blood, but abiding lax and disunited in the first passage by the Kidneys it falls away through its own weight.

In Women that give suck the Chile is supposed not at all to mingle with the blood, but Immediately from the Subclaviall vessels to pass (Milk as it is) into the breasts. This seams to be the best account of the 2 last concoctions, and therefore the Antients discourse (of the Chile being turned into Chime, the Chime into blood, blood into Certain humours, then Steamy dew, then Gelatine Glue which applyed to the parts to be nourished, [is] by the nutritive power converted into its Substance, all this I say) is of no Great Signification.

blood, Circulating through the Arteryes
The Veins, [and] heart, with nourishment supplyes

The Subservient powers to concoction, are accounted 4 Attracting, Retaining, Altering, and Expelling.

1. Attracting whereby the Member that is to be nourished by right Fibers or along between them draws convenient nourishment to its self but this drawing is now abdicated, and the matter Explained by pressure; as when the full tide comes into the river, the Gurts, outlets, or by-Channels in the Marshes, do not attract the [water] into them but its pressed in by the weight of the following waters.

2. Retaining by transverse [fibers]. This also may be explained by the pressure.

3. Altering, and Assimulating by its inward heat.

4. Expelling what is Superfluous, [or] inconvenient, in Excrement Internally by Urine, and Seige; Externally by Sweat, [and] Insensible perspiration.

N.B. Insensible perspiration (as Sanctorius asserts)[1] evacuates dayly more than all the Other wayes of Excretion; that the best nourishment expires more, and that the body is then in best health; the Obstruction of this by the pores stopping Causes a feaver and makes the blood ferment, the Cure [thereof] is by opening the pores again in a breathing Sweat. And indeed alwayes where the putrifaction becomes Malignent tis best drawing outwards (to the Circumference) by Sweats, and blisters; whereas stool, and bleeding draws it in, and then it dain[g]erously flyes to the heart.

N.B. The Defects of the first concoction are helped by Vomit, of the 2d by [Stool], of the third by Urine, Sweat, blister, and in case of more fullness than malignity, by bleeding, So that the remainder may better Circulate.

The Power Concocting has Subservient
to take, hold, Alter, Cast off Excrement.

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[1] Morton's knowledge of Sanctorius' *De Statica Medicina* (Venice, 1614) may easily have been through Boyle's almost identical mention of insensible perspiration in *The Spring and Weight of the Air*. See Boyle, *Works* (1772 ed.), I. 105; for Sanctorius (1561–1636), see Wolf, *History of Science in the Sixteenth and Seventeenth Centuries*, pp. 433–435.

Chapter 20

Of The Growing Faculty

THE Next faculty of a Vegitable [life] is Growth, a power of Augmenting itself to Just Magnitude.[1] Of which note the difference in plants and Animalls, the Cause, respect to Species, Individualls.

1. The Difference of it in plants, and Animals from Accression (as in stones) which is by Juxtaposition; or Vicinity of convertible matters; whereas this is by Inward reception, and (Even in Plants) as it use[th] to be said a vitall applycation of the Nutriment; which is in this order.

1. The Small Filaments of the root (as So many little mouths) do receive in the Nutritive juice of the Earth, which is conveyed to the thicker roots (as to the Stomack, and Entrailes) of the plant. There it receives a Kind of Digestion and is then thrust up into the plant. This Digestion, and Vitall application is not allowed by the [Neoterics], who refer it all to the Mechanick frame of the plants, and steaming Effluviums of the Earth. But Methinks the Constant figuration of all the parts in one Tenour with their beautyfull Collours, fragrant [Scents], and exact harmony in dimentions, (Contrary to what we see in stones, which have their Various figures in an Accidentall Uncertainty) these things give some Countenance [to] the Old oppinion, and seam to render the new less intelligiable, though it may have plausibility to deserve better consideration. If you say some Stones have an Exactness, and Uniformity in their shape; And Diamond[s], and Some Christalls are [all] Sexangular with a Kind of Root by which they stick to and (as it were) grow out of other [Stones]; this is commonly Ascribed to their salts, (as is before noted in the Chapter of stones) and is more fully handled by Mr Boyle in his Origen of Gems. But be it in the one or the Other Way [63] to proceed in the Order of Growth we shall consider the plant, Either in its seed or Greater Maturity.

1. In the seed are supposed the first rudiments of the plant to be latent which when it hath Imbibed the Earths Juice do swell, and open Every way. [First] Downwards in a small shoot, which is the beginni[n]g of the root and then upwards Commonly in two little leaves, and a small bud

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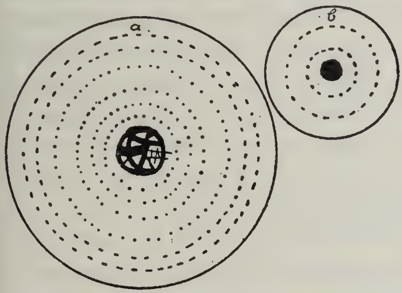
[1] The backgrounds of this chapter include Theophrastus' *De Natura et Causis Plantarum* and Aristotle's *De Plantis*. It is obvious, however, that the science of plant morphology was in its infancy in the seventeenth century, and Morton was none too well informed of the ideas of the Neoterics (i.e., Moderns). Burton, by the way, uses *Neoterics* in this same sense in the *Anatomy of Melancholy*.

between them; which when it is farther distended doth become the stalk.

2. In the plant more Mature, and perfectly shaped, the Course of this Juice is between the bark, and [the] Woody Substance, and perhaps Circulating down again by the Pith, or in the Pores that lye between the fibers (or Stringy parts of the Wood.) When in the Summer time this Juice is plentifully shut up, or thrust up, it loosens the bark from the wood, and stretches it more large, and having Got room there lo[d]ges itself in [a] Good Quantity like a Gelatine matter but when the Winter comes, tis hardened into Wood.

Hence it is that we see in a Tree sawn athwart divers Circles in the Wood which are but so [many] years growth, which it hath had, and hence some observe that it is better husbandry to preserve old thriveing timber, than young, for that there is more timber yearly added; because in the Greater tree are Greater Circles [next] the bark, Greater I say in Cumpass, and greater in content, of Solid Wood; tho the ring of the younger [may] be somewhat thicker, as you may observe in the diagrams; for there is more Solid wood in the ring (a.) than in (b.) for tho (b.) be a broader ring, yet (a.) has more than a Compensation for breadth by its far greater length.



2. The Cause of Growth is say'd to be different in plants, and Animalls.

1. In plants tis the Asending of the Juice (thrust up say the [Neoterics]) by the Volatile steams assending in the Spring and Summer, as is before noted in the discourse of rain.

2. In Animalls tis the Ebullition of humours, and Spirits, that by heat, are rarifyed, and distended; and thereby the Vessells, and members wherein they are, being yet tender, and Soft are likewise Stretched forth, and distended too. In this State many of the Members particles must Stand at a little distance into which spaces nourishment is thrust, and So hold out the member to that Extension. These Fermentations, Rarefactions, Distensions, and Implesions, (or filling up the spaces) being repeated, Augment the Animall and is called Growth. Hence the Growing, Paines, and Aches, which Young ones Used to complain [of].

In Plants by Steames the Juice is upward sent,
Animals heat opens for nourishment.

3. The difference of Growth as to species, and Individuals is observable.

1. As to Species; and that in respect to time, Magnitude, and Shape.

1. As to time; All things Grow only in youth, because then the parts are moist Soft, and Easyly distendable, this (In [Scripture]) is cal'd the dew of youth. but Every Severall kind hath its proper time of Growing to full magnitude, [Some] in 2, or 3, months, [as birds; Some] In 6, or 8 months, [as Dogs, Cats, etc: Some], in 3, or 4 Year[s], [as Horses, Neats, etc: Some] in twenty or twenty-five years, [as Men]; and these again are different in diverse Countryes, and Climates all which diverssities do arise from the various proportion of heat, and moisture distinctly peculiar unto Every kind.

2. As to Magnitude Every Species hath its particular Growth, and Extention, which it doth not ordinarily or Much vary from. The reason is because of the plastick or formative vertue, in the seed, and Seminal parts, of Every Kind. which we may Call the Law of Nature, Physicall determination, or mould, given by the Creator to every distinct Species.

3. The Shape is also from the Same mould, or (as Some would have it) the figures of the particles, and their position: for if they are apt to spin, or stretch out long, and the position be Upwards, or perpendicular, then the growth is tall; as in Men, trees, etc: but If the position be horizontall, then the Extension is according; as in serpents, Eeles, and reptile plants, etc: If some be one way some the other, then the Growth, is both in tallness, and thickness: where the proportion as to one sort is much in the Excess comparative to the other; there the Effects are Sutable to the Causes and the height seam[s] disproportionable to the thickness. But indeed there is no defect of harmony; but a [64] Wonderfull, and Pleasing Variety with Naturall remidies, for seaming Naturall defects; and All to set forth the Manifold wisdome of God.

Most remarkable in these respects are the Plants, which run up higher than their strength will enable them to stand alone, for that their parts are more apt to stretch upwards, than [sidewise]; Now least they should fall to the Ground, and rot in the Grass; Provident nature hath Given them an Aptitude to twine about, and Cleave to some other Erect body that is Stronger than themselves; and this Either in their whole bodyes; as the hop, Convolvulas, Kidney-bean, etc: Or by Certain Wires that grow forth in diverse places only for this purpose (as hands) to catch hold of their helper; as the Vine, Briony, Night-shade, etc: or Lastly by putting [forth] a Kind of Small root, which fastens in the [rough barks] of trees, or the Crevises, of walls; as [Ivy], Verginian Creeper, etc: Now in such Devoluting or Winding plants there is an Odd p[h]ainominon very observeable, that Some turn their wreath after the Sun [as Hopps]; but some as Convolvulas, and Kedney-beans do Quite Contrary, and wind from West, to East. The reason of this difference may be somwhat curious to Enquire; Perhaps It may be this; that the Sun Opperates only on the top[s] of the Hops, and draws them about after it; but upon all the body of the Kidney-bean as more tender, yea it may be that the top thereof is So tender that it cannt bear the Suns face unless in the refreshing morning, Hence it may begin first to bend towards the Sun Eastwards; but when at Noon it Grows hotter it may shun the heat, and turn off Northwards; in the temperate Evening it may look about again towards the S: and So Grow on towards East in the Night, and Morning, and then again turn N: etc: thus the Motion may begin, and Probably is continued, and helped forward by the suns heat at noon working on the S: Side of the Stalk, and may stretch, and open it more, than on the N: Side; therefore the top as it Groweth is thrust on N: and W: and S. untill the Morning Sun Draw it Eastwards again; and thus the Motion is continued; the head turning about in rounds, one after another.

Growth varyes in the time, Shape, Magnitude,
as Parts, Heat, Humour, bodyes do include.

2. As to Individuals their Growth do [also] vary [in] Every Kind.

1. As to time; Upon Accidentall accounts are very different; Some grow all in an Even tenour; Others that have been (as it ware) Stinted a Great while, do after Spring away Suddainly; and this Somtimes by Change of Air, or by a desease, Feaver, or Ague: Generally Men Grow most when they approach to Virility, because then by a Greater heat the Seminal containing parts are more stretched, and distended. This is natural. Now Suppose the Change of Air put the blood, and humours into a more than Ordinary fermentation; or the heat of an Ague be yet So moderate as not too much to dry up the Moisture, here the Active principle of heat is increased, and the Passive of Moisture not failing Men must needs Spring away at Such a time more than in Childhood, where the Active principle is weak; or in Manhood, where the Passive failes.

2. As to Magnitude in [the] Individuall[s], it depends Generally on the [Quantity] of Seminall matter, and Its first formation in the womb. Hence the Saying Partus Sequitur Ventrem, the Birth follows the belly; So that Large [Grown] women have [usually] large Growing offspring, It may also proceed from a Constant tenour of Health, In the Growing time good provision, good Digestion, etc: as preserving, and augmenting the Growing principles.

3. As to Shape tis mostly according to the Generating seed, the Plastick

or formative Vertue being Qualifyed by the Parentall protatype; agreeable to the Severall parts from whence it is derived, Hence the Ofspring is Mostly shaped like the Parent. If the Active heat, and Vigour continue after the moisture has done its part; then we continue to Grow in thickness and Solidity of parts when they have done growing in Stature. If thus Men Grow thick in Solid parts much beyond [the] proportion of their height, tis because their heat, and Volatility of Spirits, was Suppressed in their growing time, and afterwards (tho long first) were augmented, and grow very Vigorous; therefore such men are Usually Strong, and stout; but if the disproportion be in alimentary parts and fat tis commonly from a Cold and Moist temperament of the Membranous parts which Stop, and retain that which heat would have Expired. And therefore the best cure for fat that is burthensome is bodyly labour, and Sweat, and that helped forward by Frictions and Diaphoreticks.

Growth in the Individuall consents.
In time, Shape, Magnitude, with Accidents.

Chapter 21

Of Procreation

PROCREATION of the Kind is a Power of the Vegative life, in a naturall body. Whence by prolifick seed it is able to produce more Individuals of the same Kind, for the Continuation of its Species.[1] this may be considered either as in plants, or in Animals.

1. In plants it is by Single seed which is the last production of their nature; of Plants therefore consider the Manner of propagation, and the Species. [**65**]

1. The Manner of propagation, and this (I'm Apt to Judge) is allwaies by seed, of which such is the Universality. that all plants have their seed either in [the] body, root, or Graine. Here a doubt Uses to be Moved whether the Earth can produce any plants without seed? As how the Grass grew on the ruines of the london-fire? tis hard to conceive that any seed [retaining] their Seminall vertues lay dormiant in the Earth, for so many hundred years as the City has stood; Since tis observed that Scarce any seed will Grow that is kept above a year or two. And if So then [next] how should seed come to the tops of the higest wals? Or has the Earth such a Plastick vertue, as to produce such a variety? Tis true that the Earth did at first by Speciall command bring forth the herb (Genesis. 1. 11.) but then tis Immediately Subjoyned whose seed is in its self; Intimating that the Continuation of the Species was to be [by] seed. The resolution of these difficulties may (in some Measure) be had, by the Consideration of the latency of the Seminal virtue, in the 3 Particulars but now mentioned, body, Root, and Graine.

1. In the body of the plant and therein tis an Aptitude to thrust forth roots; Such are Willows, Quince, Cadlins etc: which are all by [Pitchers], and layers, Easyly propagated In Grafts and buds there is a Likeness to this

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[1] Morton's comments on procreation owe something to Robert Hooke's *Lampas* (London, 1677), and something to William Harvey's pioneer work in embryology, *Exercitationes de Generatione Animalium* (London, 1651). From Hooke's book, a part of the same Gresham College lectures used for the chapter on comets, comes some of the knowledge of microscopical investigations of maiden-hair, male-fern, and other plants, as well as the speculation about the grass that grew after the Great Fire of London. See Gunther, *Early Science in Oxford*, VIII. 198–206. The account of the hen's egg is, as Mr. Morison has shown, a condensation of Harvey's book. Note that Morton knows there is discussion regarding the sexuality of plants, a fact not fully established until the eighteenth century, and that he does not believe in spontaneous generation, though he makes no mention of the experiments of Francesco Redi.

kind of Seminality for though there be no puting forth of roots, yet there is Somewhat analogous thereunto, in that aptness of pores to Sute the pores of the Stock, and receive nourishment by them; and in the Suitableness of the bark to heal up, and joyn with that of the Stock.

2. In the Spreading root[s] which [send] up diverse shoots out of the Earth, and these may be all Seperated, and made distinct plant. Thus are propagated among trees, Elmes, and some Kind of Pears, etc: among herbs, Mint, Horseriddish, Cumfery etc:

Plants propagate by seed which place doth gain
In the plant[s] body, in its root, and Graine.

3. In Grain, or Seed properly so Called, of this consider diverse things.

1. That it is the last production, for in Annual plants it is in this order; 1st from the seed arises the Stalk then the branch, the leaf, the flower, and lastly the seed. And in more durable plants the seed comes not, till the plant arises to its natural perfection which may be after some years, for 1st It Sp[r]ings up in a Soft Stalk, then for some years it produces only leaves, but after [yearly] seed, whereof some are included in a fruit, and [this] more and more untill it finally decay.

2. That it Singly produces the Notion of Male, and Female plants in the same species, I think is but a figment; only whereas some are [more Large and Robust, they are] by a Metaphor cal'd Males of that kind and whereas some are said to florish, and bear fruit better togather than apart, It may well be ascribed to the drawing of Noxious, [or] improper steams from one another, and so both thrive the better for it; Whereas (on the Contrary) if two plants draw or receive in the same kind of Juice, they hurt, and hinder Each others [florishing]. Thus Wheat, and Rye Grow well togather, but Vine, and Cabbage destroy each other.

3. That it produces only its own Kind; and therefore tis a Groundless conceit, that Darnel (or Evers as tis cal'd in the West) comes of the seed of Wheat; whereas it is indeed from its own seed mingled with the Wheat; Yea, So pertinatiously doth the Kind cleave to its own seed that tis asserted by Some that in [Grafts], or buddings the Seed follows the stock though the fruit doe the [Graft], or bud. So an Apricock stone brings forth a Plum, and not an Apricock; Yea I have been told that the seed[s] (or pap[s]) of one, and the same sort of Apple, have brought forth trees of a Great many kinds desernable in part by the leaves, at the beginning but manifestly after in the diversity of fruits. This is an Experiment tryed not commonly with observance, because Seedlings require 10, or [12] Years Ere they will bear fruit. [Now if this be So,] It must be from

the Variety of Stocks that the [Grafts] at Several times have been implanted into, so that some have communicated, of the Nature of the Immediate stocks, and others of the Stocks more remote, and parhaps in Many Successions.

4. The Seminal Vertue (it seams by this last instance) doth lye fundamentally in the heart of the root, and is communicated by the heart, or Pith of the tree; and through the [Pith] of the Stalk to the heart or Center, of the fruit namly [to] the seed, or stone which is in the middle thereoff. whereas the Carnous part of the fruit is communicated, by the more jucy, and exterior parts of the tree This is but a Speculation proposed to be thought upon, more Certain it is that the Seminall vertue lyes formally in the Seed, yea, and that in a very small part thereof; be the Seed never so small; Many Plants have their seed so little, that they have been thought to have none at all; but of late they have been found out, and discovered by the Microscope: Such are Moon-Wort, Maden-hair, Ceterecht, Male-fern, etc: Yet each of [the] little, and [even Invisible] seeds, have their distinct parts; as the Shell, pulp, and [that] in two halfs and between them at one end the little vivid Point, in which are the rudiments of the plant, and the seminall vertue; this is plainly discernable by the hand in larger seeds Such as beans, Wallnuts, etc: In Wallnuts I have often taken it out with a pin after the pulp hath been split in the Middle; for there at the Sharp end (which is remotest from the Stalk) it lyes in the [Shape], and bigness of the little black figure. By this consideration may be solved the difficulties before mentioned how seeds of Grass Should come to the tops of houses or high walls in the ruines of london? for may not the other parts of the Seeds body be broken, taken, or rotte[d] off from this Seminall point, and then this partacle may Easyly be [tossed] up like dust in the Air with Every Wind, yea parhaps wrapt up with the Clouds, and thence come down again with the rain; add to this, that birds may be the Carryers thereof, either in their bills, or [66] Sticking to their feet; I have heard of one that limed his wheat before he sowed it, and that yet the rooks fell upon it, Chinked the Grain, and liked out the flowery part, but droped the hulls as tasting of the lime, and it seams the Seminall part was left with the husks; for the Man had a Good Crop of Corn, (Contrary to his Expectation); whereas If the foul had Swallowed the whole Graine, the Seminal part had gone with the rest, and the whole crop [been] destroyed.

One thing More may be considerable of this Seminal Virtue, that it seams to be a small Quantity, of Spirituous matter apt to be contracted, and preserved by cold, and dry (Hence Granaryes should be open towards the North) whereas hot, and Moist puts it into Motion; Whence Growth, or Putrifaction. but hot, and dry will dilate it So as to break its bonds, and fly away, with a little bounce or Crack, as we see in a Pea, or Chesnutt, put into the fire. Whence tis said that the turks crack their rice in an oven before they sell it, least other nations should make Use of it [as] seed. And that the Flandrians are said to have dealt so at first with their Clover seed, [as] willing to have mony for their seed, but unwilling that others should have benifit thereby

Plants last produce is seed; No sex at all
Hold on their kinds by Vertue Seminall.

2. The Species of plants are Various, all which are comprehended under the distinction of perfect, and Imperfect.

1. Imperfect that have not the Evident parts of a plant; and these either such

1. [As] Grow out of the Ground, as Mushroons, furs-balls, etc: Mushroms that are of light purple on the Nether side, are by Stewing with sweat herbs, and Spices accounted a delicate dish in france; and for this End by an Artificiall watring [of] the Earth they produce them suddainly in abundance. Mould (as of Cheese, etc:) is also found to be Mushroms by the Microscope.

2. Such as Grow on Other plants, as Agarick, Punk, Jew[s]-Ear, On Elder (Good for throat deseases) Missletoe, on old Apple trees, and Oak (this on [the] Oak was famous in the Hethen Sorseries of the [Driades]) besides a Multitude of Mosses on the barks, and other small productions on the leaves, and flowers not descernable but by the Microscope.

2. Perfect, [that] have the Evident parts of plants, such as Root, Stalk, branch, Leaf, etc: these are again divided in divers respects, as Magnitude, time, place, etc:

1. Magnitude. and Solidity into herb, Shrub, and tree.

2. Time of duration, Into Annuall, and Permanent.

3. Place of Growth, Into Plants of Water, Mountain, Native, Exotick, Garden, Feild, etc:

4. The Shape of roots into ballbous, and Fibrous.

5. The Use Into Alimentary ([or] for food) or Medicinall ([or] for Physick.)

All which and More are treated of in Botanicks (or Herballs) which describe their figure, Colours, Qualities, Vertues, etc: Which Vertues are prepared, Qualifyed, Extracted, etc: by distillations Mixture, digestions, and other Chymicall preperations.

Imperfect plant[s] by nature, art are Spyed.
Perfect their bulk, time, place, Shape, Use, divide

2. In Animalls procreation is by a Mixed seed of Male and Female; Not Male Seed, and Menstruum (as the Antients) for this is but the After Nourishment, and not the first producent; Nor is only the Male-seed the Active, and Female the Passive Principles of the Offspring; but rather tis the Spirituous matter of both conjoyn'd that is the Active principle, and the Grosser matter of both conjoyn'd that is the Passive.

The determination of Sex in the Fœtus is not from the Prevalency of Male or Female seed nor of the better preparing Vessells on the right or left Sides of the Generants (as has been thought) because we see dayly many Females born more robust and Vigorous than Males, which would not be if due preparation of Seed were in the cause of discrimination. It is therefore rather to be ascrib'd unto the Wise providence of God, than to 2d Causes (Especially in Man) because of the fit proportionable Number of Each Sex produced in all Ages, and Generations; yea, I may say in all years, In all times of the Year, In All countryes, in all Constitutions of body, and Ages of life; Which Accidentall Circumstances if they had the Ordering of the Matter would Certainly one time or other Much disorder the proportion, besides if Art or Humane Consideration [could] help in this Affair princes and Great men would never want Heires-Males to Uphold their Names, and familyes. I Say therefore God gives sexes when he gives Souls, and this is a Matter of Awfull consideration.

In Animall procreation consider the Subservients, and the Order.

1. The Subservients are diverse; as the Seed, Plastick, Vertue, etc:

1. The Seed itself, which is a Matter of Much higher Concoction and preperation, than [the] blood, and therefore tis made out of the purest of it in the Vessells appoynted for that Use (of which Anatomists More at large) It contains much Spirit, and little Gross matter. Whence follows that the Abuse of it in any Wicked way, is consecrating the best of our bodyes to the divell.

2. Its Plastick, or formative Vertue (which is a Wonder of Wonders) a power whereby it shapes every body (except there be impediment) according to its kind. In Mear plants the Apostle seams to take it out of [the hand of] nature, and ascribe it to the God of nature who Gives to Every Seed its own body (1 Corinthians. 15. 38.) and if it be so in plant[s] much more may it be said of Animals Especially of Mans body which God hath wonderfully made and Curiously wrought, in the Neither parts of the Earth (Psalm [139]. 14, 15.) i.e. in the womb. But if any Conjecture

[may] be made of this as to Second Causes; it Seams to be that the blood and Spirits in their Circulation, having passed thro all the body receive from all the parts where they have been most resident, Certain Signatures, and impressions which they retain, even when they become the Matter of Seed, and So (as it were) take their places in the begotten according to the places they come from in the begetters. But this may be long thought before it can give the Mind a Quieting Satisfaction. Thus as to the disposition of the Matter; but on the Other hand if it be from the form, and the Soul prepares itself a house (as the Matter will afford) Suitable [to] its occasion, this may do as to Man who has a living Soul [conjoyned] (parhaps) to the Matter; in the first [**67**] Moment of Conception; But how will the Neotericks satisfye themselves as to brutes to Whom they deny a Soul, or any Substantiall form. Besides the Generall formation which is naturall to the Species, there are diverse individuall, and Accidentall configurations, which are somtimes found Extraordinary. All this is commonly Ascribed unto Fancy opperating Strongly in the time of Conception: as was seen in Jacobs Spotted Cattel, from the Striped rods, (Genesis. 30. 37.) So in the Dog (which we have) littered without Ears, Spotted like its Sire that was Cropt. And Possibly the More natural resemblances in Countenance of father or Mother, may arise from somthing of this Nature, for we know the Fancy is (of all the facultyes of the Soul) the Great Immage Maker, out of Materiall Spirits, and So probably delivers them figured to be an Ingredient in the Proliffick Seed.

As to Monstrous, and Unnatural Shapes, tis either from defect or redundance of matter or Confusion, or dislocation of parts, by Some outward Violence before they are well consolidated. As to those Externall, and Cuticuller Marks which happen to the Embryo, after its Substantial formation (as we see in Many persons blood-spots, and Notable Moles, having resemblan[c]e of Some fruit, or other thing longed for by the Mother; and tis Said that if the Mother in a longing Condition touch any part of her own body with her hand, the Correspondent part of the Child will accordingly be marked.) For all these things we know not how to account, but by those Phantastical impressions.

Much Spirit seed in little matter carryes,
Shapes Natural; by Accident it varyes.

3. Its receptive power of Animation (or Life) which may be conceived an aptitude for a motion of spirits in the Generate to be [continued] from the Moving spirits of the Generants. As [one] bowle in a Green [running] Strikes another that lay Still which by its roundness being apt

for Motion, easyly receives the Motion from the Mover. or as one Candle is [Inflamable] by another actually Inflamed, and applyed thereunto. And indeed the life of brutes (by the Corpuscularians) is commonly cal'd a flame which in Course of nature will of itself burn out the Combustible matter, or radical moisture unless before, by Accidentall violence, or some desease it be [Extinguished].

4. Besides all that is in a brute there is added a true Spirit (the Soul) in a man Ingenerable, and incorruptible by the power of nature; this is by the Immediate hand of God [creating], (though not new Species, yet) Every Individuall Soul, and Infusing it in the Moment of Creation, though the Union allso in the same moment to the body to make therewith a composite (Man) is rightly ascrib'd to the Generative power of the parents. In which union of Soul, and body lyes the formall reason of Generation; as the Corruption of man (death) lyes in the disunion, and Seperation of them again. And hence the propagation of originall Sin, is not from the body of the Generant, to the body of the Generate; nor from the Soul of the one to the Soul of the Other; nor from the body of the Generate to its own Soul; but from the whole man Generant to the whole man Generate therefore the Soul not in the Act, of being (or its Spirituall nature) which as from the hand of God is pure but in the Act of Information (which comes of man and makes it the form of man) is, and becomes polluted. Now that there is a distinct kind of production of mans Soul from that of brutes the Scripture Seams to note (Genesis. 1. 24.) Let the Earth bring forth the living Creature after [its] Kind, Cattle, and Creeping things and beasts of the Earth after their kind. But (Verse 26.) let us make man in our Image, (that is Spirituall, and rationall nature), and (Chapter 2. 7.) God breathed into him the breath of life, and man became a living Soul. And So in other places God is cal'd the father of Spirits; and Sayes the Spirit returns to god that gave it, etc: to all which Theologicall Revilations, Phylosophycall reason cant but subscribe; for what is Generable by naturall power is Corruptible by the Same; and So Souls in their own nature would be mortall, and then to reserve them for Ever must be in God a Controling of the Course of nature which is not likly in a Constant Course; Only I must Enter here a Small caution, that what is said of the progeny of humane, and brutall Soul, dont derogate from what we offer to Consideration in our pneumaticks concerning the brutall Soul. but (Supposing what is before declared) least any Should say this derogates from the dignity of humane procreation, as making the parent a less compleat Cause of the Generate than tis Supposed to be in brutes; Note that man communicates as much every way as the brute dos, and moreover

unites the noble Soul; So that here is the whole brutall Generation, and a Great thing done besides. Here a Question may be moved, at What time the Soul is infused? It has been formerly thought not to be till the Compleat Organization, of the body about the fourth, or fifth month after conception, because of the Old saying; We first live the life of a plant then of a brute, [and lastly] of a man which is true of the Actuall Exercise of facultyes, whether it be of the principle or no. And here the Law of England (which is allwayes sed to be favourable to the prisoner) condemns not the Whore [who] distroyes her Child; for Murther unless it appear[s] that the Child was perfectly formed, [as] having haire, and Nailes, etc: Upon this Supposall that till then there is no Union, and therefore no Seperation of Soul, and body; but indeed it Seams more agreable to reason that the Soul is infused in the Conception, and that it forms itself a house (as is before noted) that is the Vertue formative of the body, [resides] rather in the Soul which adapts a body for the Uses it has for it, than in the Spirits, and impressions, made upon them. Nor let it be thought unworthy of God to afford a Soul in Spurious Generations, for tis the Nature not the Enormity of the Act to which he doth concurr; and here as in all other Sinfull Actions the Material naturall part of the Action is Good, though the formal, Immorall part thereof be wholly Evill.

Receive from mover, seed [lifes] motion can
And joyn the Noble heaven-born soul in man.

And thus much of the Subservients to Generation, now of the Order.

2. The order of Generation and perfecting the Animal is (as Dr Harvey Sayes) in an Egg, or somewhat analogous thereunto therefore to declare the nature of Generation he discourses of a hens or other fowles Egg in the Severall changes thereof. [**68**]

1. It is layed with a Shell, film, White, and Yolke, in one side thereof is a small Whitish speck, no bigger than a Small pins head Cal'd the Punctum salens, (or Skiping point) this you may see by droping the Yolke of an Egg into any liquor for this Point will flote uppermost, as being the lightest side, and most Spirituous part containing in it all the Seminall vertue, Tis a Vulgar, but Erronious conceit that the white hard Substances at Each End, are the Seed, and therefore commonly cal'd the treaddings; whereas indeed they are only a pair of Ligatures whereby the Contents of the Egg are so hung to the Shell as to allow them a little internal motion which is needfull when life is begun to work the Nourishment to the Imperfect Embrio. But in Case these Ligatures [are] disjoyned from the Shell or white of the Egg, the Motion [is] lost, it becomes

addle, and will never hatch. Some therefore do purposely jerk an Egg of their Game-fowles, to spoil this appendence; as Cock-Maste[r]s, Decoy-keepers, etc: whereby they Secure the kind to themselves though they Spare the Eggs to others.

2. In 2, or 3, dayes Incubation (or sitting upon) round about this Spirituous point the Egg will Change Colour the breadth of ones nail, this is Called the Iris (or Rainbow) and then tis unfit for our food

3. In a day or two more the point being amplycated will have a Spot of blood in it with Some runing out into a length; having one End bigger than the other and this is the rudiment of the heart, and Vena-Cava.

4. After this the parts begin to appear E[s]pecially the head, and heart; the head very Great in proportion to the rest; and the Eyes are more especially notable.

5. When the Chick is fully formed the White will be gone; but the Yolke remains hanging in a bagg at [its] fundament, where it is after drawn in, and lyes in the [hinder] part, and then the bird is hatched.

N.B. that for 2, or 3, dayes after hatching tis profitable for [the] Chick to feed [only on] what is within its body, till that be fully digested, and indeed all young things soon after birth require warmth, and Sleep rather than food.

From these discourses of an Egg may be conceived the manner of Animall productions; for the Secondine or Wrapper of the Embrio bears analogy and is answerable to the Shell, or Inward Membrane of the Egg, The Maternall blood to the Yolke, the Childs navell to the Chicks fundament, and so of the rest.

Twixt Eggs, and Animal productions are,
Analogyes that do their breeds declare.

Insects or Imperfect animals have their manifest Eggs which in [the] Autumn they Stick to Walls, or other convenient places where they abide all winter, and are hatched by a kindly Springs moist warmth; this is where the Insect yearly dyes; but if it hides it self all winter in a convenient place, to preserve its life, as bees, Wasps, Hornets, etc: then it layes these Eggs Early in the Spring, and they are Soon after hatched, Therefore he that kills a hornet or Mother wasp in the Spring time at once distroyes a Whole neast of them. That conceit therefore I take to be an Error, that those, and Some perfect animals (as Mice frogs, etc:) are bred only from putrefaction, and that more abundantly in sickly years. I think no Animall is produced but from prolifick Seed, he that hath kept Silkworms, a year round, and compared their [gendring] with that of flyes about Michaelmas may well allow the propagation of their kind, by natural Generation, and not an Extraneous putrefaction, the places indeed where they are bred, are where their Eggs ware before layed [as] in convenient neast[s]: and a Moist Spring after a warm Winter (the Common forerunner of a sickly Summer) give a warmth Sutable for a Numerous production whereas if the winter be hard many of the Eggs are Spoiled, and if the Spring be cold, and dry many of the little Grubbs perrish at their first coming forth, So that these may be multiplyed in putrifying seasons. And yet no proper Effects of putrifaction.

The most imperfect animals do breed
Not by putressence, but prolifick seed.

Chapter 22

Of Sensative living bodyes

SENSATIVE livers are such as consist of an Organicall body, and a Sensative Soul, this in [Contradistinction] to plant is cal'd animall,[1] and may be considered in Generall, and Speciall

1. In Generall, as common to Man, and beast; and so its principles, and Affections.

1. Its principles Matter, and Form.

1. Matter, Organicall body furnished with apt instruments for Eduction of Animal opperations.

2. Form the Sensative Soul (antiently defin'd) the first act of the Organical Sensative body whereby it has Sensative Cognition, appetition, and Locomotion.

N.B. Here a Great Question is moved by the latter men whither brutes have any such Soul, and whither all their opperations may not be Solved by Mechanisme. The Grounds of all this their doubt is from the division of all Substances, into Spirit, and body; Now Say they this brutall Soul is not Spirit, for then 'twould be Indivisible, and incorruptible, therefore it must be body or tenuious matter, moved as the Matter of light, or flame. This they assert to Cause all the Opperations in the Animal which we call sence Externall, and Internall; but that really they have no true Sence, appetite, or motion from any internall principle. Accordingly they bend their wits to prove that a brute [69] (say a Dogg) Sees not, Hears not, feals not, etc: and to Solve the appearrances of Sence, motion passion, Memory, etc: by Similes of a Clock, Bag-pipe, Gun, and other Engines, and So referring all to Mechanisme But how well this is done must be judged after the Consideration of these facultyes whither we must referr it.

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[1] This chapter, together with portions of Chapters 26, 28, and 30, hinges upon one of the central points in Cartesian discussion: the distinction between man and the animals. See, for a convenient summary, Albert G. A. Balz, "Cartesian Doctrine and the Animal Soul: An Incident in the Formation of the Modern Philosophical Tradition," *Studies in the History of Ideas*, III. 115–177. Although Aristotle's *De Anima* has some relation to the ideas here, it would seem likely that Morton had read such contemporary books as Thomas Willis' *De Anima Brutorum* (London, 1672) and Antoine Legrand's *Dissertatio de Carentia Sensus et Cognitionis in Brutis* (London, 1675). Burton's *Anatomy of Melancholy*, Pt. I, is again a convenient place to observe the background of the ideas presented from this point on through Chapter 30.

The livers Soul, and body Organiz'd,
to Solve by Mechanisme some devis'd.

2. Its Affections, Primary and Secondary.

1. Primary, which do Immediately flow from the sensative soul (supposing there be Such an one) and do Immediately affect the composites as their proper naturall powers; Such are sence, appetite, and locomotion, all which may be set forth in this Sentence (a Dog Sees a bone, Likes, and desires it, and then runs to catch it up:) but of these more particularly.

1. Sence or Sensitive power whereby the Animall (or its Soul) apprehends a Sensative object. This is considered in Generall, or [in] Speciall.

1. In Generall, and [so] take notice of [its] act and object.

1. Its addequate Act, and that is Sensation, which consists partly in action, and partly in passion.

1. In passion in receiving of the Sensible Species impressed on the organ.

2. In action in judging of these Sensable Species so received.

2. Its object which was wont to be divided into Intentionall, and reall.

1. Intentional, that whereby Sensation is, and this they call Sensible Species, that is an Immage or representation which the reall object begetts of its Self [and] is conveyed to the Sence through a proper medium.

2. Purely reall, or that which is perceived by the Sence namly the thing itself that sends forth these Species; this is two fold; of its self, and by accident.

1. Of its self or by its own Species, and this is proper [or] common.

1. Proper, perceptible by only one sence, as Sound, Colour, etc:

2. Common, perceptible by more Sences namly Sight and fealing; as
{Magnitude,
Motion,
Quiet,
Figure,
Number.

Sence common object which we feal and See
Bulck, motion, Quiet, figure, number be

2. By Accident, perceptible, not by their own, but by others Species; So Substances are discerned Sensibly only by the Species of their accidents.

N.B. These Species are Supposed to be a kind of middle thing between body and Spirit, and therefore they call them [Spiritalia], or [Spiritalls], (though not Spirituals) as if they ware a Sort of [Specters] that are not Substances, no, nor it Seams So much as Accidents, but only a representation of them. Therefore they Say that Substances are perceived by their accidents, (as Colour, figure, Hardness, etc:) and these accidents again by their Species, or Representations. They call them also Idols or Images but tell us not of what matter they are made. They further Say that divers of these [Spiritalls] may be in the same point of Space: as that one Candle Sends its Visible Species to Johns Eye, [and at the same tyme another Candle Sends its Species to Peters, Cross the Line that went to Johns Eye], So that in the point of intersection the unbroken Species are [as] in the Same point of space which if they ware bodyes they could never be; that which induced them to think there were such transient Species was the representation of things in a dark room through a hole by the help of an object-Glass; which representation on a paper, set at due distance from the Glass they call the Species of the figures and Colours of the bodyes thereby represented. The like is the representation of a looking Glass (all which are treated [of] in Opticks) but indeed all this doctrine of Species seams to be a mistake; for that which affects the outward sence is reall, and [materiall] body; which thereby gives occasion to the inward Sence to Shape all the Images, and representations which are mad[e] within the brain, [of those things] which are without it as will appear when we treat of the particular sences

Sensible Species now are obsolete,
Dislik't [by] those Who doe of Sences treat.

2. In Speciall the Species or kinds of Sensitive Powers are 2 Externall, and internall.

1. External are wherby the Animal perceives by the use of outward means, (or Organs) and they are [5], Seeing, Hearing, Smelling, tasting, and touching.

2. Internall sences reconed [3] Common sence Fantacy, and Memory.

Outward Sence See, hear, Smell, tast, touch, [hereby]
Inward Sence Common, fancy, memory.

Chapter 23

Of Seing

THE Powers of the Sensitive Soul in speciall are Seeing, Hearing, etc:

1. Seeing, an Exterior sense perceiving visible things by the help of the Eye;[1] of this consider the Organ, Object, Mean, Manner, and dignity

1. The organ, or Instrument of Seeing is the Eye; a part of the body made up of Nerves, Coates, and Humours, which are more fully handled in anotomy, yet tis need full here to take a Short notice, of its fabrick to discribe the [bulb] of the Eye, we must begin with

1. The Optick nerve, and here a little of nerves in Generall will need to be Spoken to. Wee noted before in Chapter 19 that there are 3 sorts of vessels branched abroad throughout the whole body veines, arteries, and nerves, the former two Serve for Circulation of the blood (as was Shewn) but the nerves (besides what they contribute to the ferments, and Seperations there mentioned) have their own manifest use in sence, and motion, Some think there are different kinds of nerves for these different works, because tis observed in Palseyes, that Somtimes one power is weakened and distroyed without much prejudice of the other all these nerves have their originall from the [70] brain and Seam to be continued with it; being only a kind of propagation or protrusion thereof into Severall parts of the body; Each nerve hath two Coates, and a pith. The Coates are continued with the two Coates of the brain called Meninges and Mininxes and the Pith from the Substance of the brain it Self. Now of all these nerves the opticks are two one for Each Eye [which] coming out from severall parts of the brain they Meat and touch but not Cross, and Mingle, and then part again to go to Each Eye; [here] the Outer Coat ([or] Mininx) forms the [bulb] or ball of the Eyes; and So far as the white of the Eye goes tis Covered with another Coat (Caled adnata, or

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[1] Despite the influence of the *De Anima* and the *De Sensu et Sensibili*, this chapter is dominated by contemporary discussion. Most important, as Mr. Morison has indicated, is Isaac Newton's letter in the *Philosophical Transactions*, No. 80 (February 19, 1671/2), a famous theory of vision which was followed by a long series of attacks and defenses in the same journal. Morton's definition of light follows Newton's, as does his description of white light (see the *Philosophical Transactions*, No. 88, November 18, 1672). Many things, moreover, suggest Boyle's *Experimental History of Colours*, twice cited by Morton. The description of the anatomy of the eye is paralleled in Legrand, *Institutio Philosophiae*, Pt. VIII, ch. XVI, where there is a somewhat similar diagram.

growing upon) to which the Muscles that move the Eye are fastened, and indeed do Constitute it out of their white tendons. The ball of the Eye is contained all within the Coat called Cornea, (or Horney) which is clear and transparent; and this is the first part of the Eye that the visible rayes do touch.

Organ of Sight is th' Eye whose nerve from brain
Comes with its Horney Coat all to contain.

2. Within this Cornea, is the Uvia (or Grapelike Coat) So cal'd because tis Striped like the Skin of a Grape. If (the pulp, being Crushed out) it be Stuck against the Glass of [the] window. This is it which gives the Severall Colours (Called the rainbow of the Eye) which Colours are perceived through the Horney Coates transparency, but itself is not transparent; only in the forepart or middle it is perforated or has a hole in it which because of the Darkness within, and the Clearness of the Humours receives in light, and Colour without reflection, and therefore appears black. This hole is commonly cal'd the Window, or Pupill of the Eye through which the light has its Entrance to the farthest Side of the Eye where vision is made. The little Image or baby (as tis Cal'd) that is Seen in the Pupill by another looking on, is but a Specular reflection from the outer polite Surface of the Cornea because it has only [blackness] or darkness behind it; So any Glass that is [blackned] on the one side, is Specular ([or] a looking-Glass) on the other; and as for the littleness of this Image, it is from the Globular figure of the Eyes (as is shewn in Opticks) This hole of the Uvia (or Pupill) is contracted if the Eye be turned to the light, or look on [any] thing at a great distance, but under contrary Circumstances tis Sensibly dilated. The reason is to let in so much light as is convenient, and no more.

The rainbow of the Eyes, the Uvia; this
Is perforate; the hole, the pupill is

3. The Aqueous (or Watry) humour lyes both within, and without the Uvia, and takes up all the Space between the cornea, and the Christalline humour, (or Apple of the Eye.) Now if this watry humour be dryed up, or thickned, (like as the Glaze of an Egg boyled) it hangs as a Curtain before the pupill or window, and Commonly Sticks to the Cornea. This Mallady is called a Cataract whose Couching (or removing downwards) below the Pupill by the point of a needle in a dextrous manuall opperation piercing the Cornea on the one Side, Dos but as it were draw the Curtain from before the window and let in the light.

The watry humour thickned keeps out light,
Couching the Cataract restores the Sight.

4. The Christalline humour, (or the Apple of the Eye) lyes behind the watry, and is lodged in a bed (or hollow) of the Vitreous (or Glassy) humour which lyes behind it. This Christalline is a body of pretty Solidity, perfectly pellucid as Christall (whence it obtains its name) and boyles white, and hard (as the White of an Egg does) at least the Outer part there[of]. Hence an Over heat in the Eye may so Spoile it as that it can transmit no rayes. This desease is cal'd Gutta Serena wherein the Eye looks outwardly well, but [sees] nothing, and is thought incurable. This Christaline is Sustained by Certain filaments hardly discernable; [with one] End fastened to the Insides of the Uvia and the other ends to the body of the Christalline round about; Herby the Christalline is either drawn flattish, or permitted to rise more round on Each side, according as the Vision requires, but if by Age the Christalline be too much dryed to be thus plyable then a Supply is made by Spectacles which by their refraction So order the rayes that they may notwithstanding come in their proper pen[c]ill, and point the Object at the bottom of the Eye. These filaments are Called the Aranea (or Cobweb) of the Eye; because they Somwhat represent a Spiders web which bear up a Spider in its middle, as these fine threads do the Apple of the Eye

The Christalline or apple of the Eye
Has its Aranea to hang thereby.

5. The Vitrious (or Glassy) humour is thicker than the watry and thinner than the Christalline, about the Consistence of the Glare of an Egg, or a little more Sollid nearer to that of boyled Starch it boyles not white or hard So Soon as the Christalline: It fills all the hinder part[s] of the Eye; and has a hollow cavity in [its] forepart where the Christalline is lodged. This is transparent as the other Humours, and is Seldom much out of order only it [71] wasts with age, and this Causeth the hollowness of the Eyes.

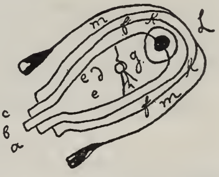
Behind the Christalline do Vitreous lye
Which when decay'd by Age makes hollow Eye.

6. The retina (or net-Coat) which is the Expansion of the very pith of the Optick nerve in Whitish filaments; and these are like to [a] network hanging fastened to the Inmost Wall of the Eye. [Here] it is that the Species, or picture of the outward object is represented in little; and here indeed Sight is formally performed, whereas [indeed] all the other coates,

and Humours do by their Severall refractions only prepare the Species, and make it apt to be Seen.

The Retina, Pith of the Optick nerve
for the prepared pictures Sight doth Serve.

Having thus Spoaken to the Severall parts of the Eye apart. We come now to put them to Gather in this diagram. Suppose (a) the pith of the Optick nerve div[ar]icating it selfe to make (e.e.) The retina where the picture is made, (b.) the Inner coat of the Nerve making the Coat Uvia (f f) which has its Iris, and hole before (G.), (C.) the outer Coat of the Nerve making the Cornea coat (K K) which at (L) puts its Self a little forwards and there the Iris dos appear through it, where the Adnata coat (M M) ends (d) the Christalline humour Sustained by its threads, the Aranea that [go] out to the Uvia every way from it having the watry humour before it as at (g) and the Vitrious behind it as at (e.e.) and thus much of the fabrick of the Organ of the Eye.



Three humours, and 4 Coats with filaments
White, pupill, Iris, all the Eyes content[s].

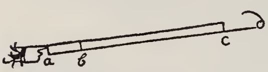
2. The Object visible which are light, and Colour.

1. Light or Luminous body; these are distinguished as the fountain and streames So as Luminous is the body sending forth light, (as the Sun, flame, etc:) [and] light is that which is in or on the thing enlightened (as the Air the body Shone upon). This thing that is so lightsom in itself, is most obscurely defined by Aristotle the Act of [a] perspicuous, as it is perspicuus, which (I must confess) to me is utterly unintelligable. Latter men call it particles of finest matter continually streaming every way from a Luminous body every one of the multitude of Streames is cal'd a Ray; In matter these rayes will agree with flame, only the motion of them is diverse, for the motion in flame is constipated, and circulating in a small Space and therefore making attrition whereby heat is generated and made more intence. Whereas the motion of light is streight forwards in right lines from the center of their motion whereby they get more room continually to Expatiate themselves and So to avoid attrition. [Those] rayes of light may be illustrated by a comparison to water which in a small stream or thread rushes out, and spins off at a distance through, [and] from a little hole of a pipe, or Cistern; as also (or rather as is before noted) [to that] sending forth the little streams by the twirling upon the hand of a maids wet mop whereby it [Springeth] water every way.

Visible object, light, flame every ray
In a fine matter every stream's a way.

Now this Hypothisis is very agreable to the p[h]ainomena of sight, and Light. such as,

1. Sight is in a moment, for the mater being alwayes everywhere in the Air, there needs but a motion to be given to it by the luminous body, and presently tis communicated to all the particles that stand in the same line; like as in a long body receiving motion at one End that End immediately communicates it to the other end to avoyd penitration of dimentions for if [my] hand gives motion to the End (a) and cause it to remove to the place (b.) in the [same] moment it causes the End (c.) to move onwards towards the place (d.) Now this Simile holds even in the discontinued [Globules] of light; because the Air is so full of them that they cannot turn aside in an Eddy (as tis in Water) but are kept streight forwards by others of their own kind



2. Sight is in a [Sensibly right] line, for such is the motion from the Luminous body to the Eye; tis said (sensibly) [for] there may be an insensible [flexure] of the line; the rayes may pass one by the other when they pass from two distant lights to two distant Eyes, that is the ray of one light passing to the one Eye dos not cross the other lights ray passing to the other Eye in the very same point, for then the motion of the one or other should be broken, or two particles of matter should be in the same [space]. but tis thus; the one ray passes by in the next point to the others, and this makes a little flexure, but it is so little that it is insensible, this Solves the difficulty, and takes off [72] the Argument above mentioned Concerning [sensible] Species, and spiritall accidents.

3. The Greater light obfuscates the [less], that is the Stronger motion of rayes from the more luminous body, either wholly diverts, or much disturbs the motion of rayes from the [less] or [weaker] luminous body; so that they cannot at all or not well reach the Eyes. hence the flame of a candle in bright Sunshine even disappears.

Lights in a moment in a line that's right
the Greater overwhelmes the lesser light.

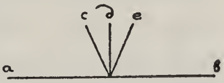
4. Shaddow is the partiall privation of light, for it is by the interposition of an opacous body which stops the motion [and] intercepts the streams of light so that they cannot come directly to illuminate a body; yet tis said to be but partiall, because some reflected rayes may com into the place

where the direct ones are intercepted, and excluded, but darkness is a totall privation; because though the matter of light be there yet the motion both direct, and reflex is absent.

5. Rayes of light pass through a Diaphinous body, though a little turned aside or refracted, they pass through because the pores of the transparent or Diaphinous are streight or at least Such in figure as can transmit the moved matter continuing its motion; they are refracted because of the obstruction they meet with. The reason is for that a certain Quantity of motion being communicated to the [Globules of] light they pass on streight in the thinner and equall medium; but when they meet with a thicker, they are somwhat hindered, and though at last they break through yet upon the obstruction, the motion that [should] have otherwise spent itself in going forward, turns itself sidewise; like as an Arrow shot at a butt when the forepart begins to Stick, the hinder part is also Stoped, but this cannot present[l]y leave its velocity, and therefore Spends the remainder of its motion in vibrating its self, and Whirling. but how the passing rayes thorow the thinner and thicker medium first gives the diversity of termination and the inclination to and from the Axis is to be found more fully handled in opticks.

By partiall lights privation, Shaddows be
Refracted rayes through double mean we see.

6. Reflection of light is in the like angles; So that if the falling of a ray be at right angles (or directly) on a polite body the reflection is also direct and in the same line; but if it fall obliquely then the [reflected] Image from the pollish't body (or looking Glass) is seen in the same obliquity; for if (a.b) is the Surface of the looking-glass then a thing placed at (d.) is seen back again in the same line at (d.) but if it be placed at (c.) then it is seen at (e.) by the Eye there placed, because the Luminous rayes in their motion are so turned back as to make the Angles of incidence and reflection of the same Quantity; Just as a ball rebounds from the Ground (upright, or [sidewise]) according as it is cast upon it.



7. Light intended burns; this is seen in the burning-Glass where all the rayes that fall on the Glass are by refraction directed unto a point They there being constipated, Rubb against Each other, and so intend the light and heat even into a flame.

Incident rayes in the like angles turnes;
Light when intended proves a flame and burns.

And thus much of light.

2. Colour (another object of Sight) is as blindly defined by Aristotle the Extremity of a perspicuous as Terminated; which also must be understood by those that can. Since the Candle of Phylosophy has been better Snuff't, we have better light to see what Colour is. And yet indeed it must be confessed to be but candlelight; However tis more clearly Expressed than formerly by Light diversifyed, or reflections [and] refractions of light according to the figure and site of the minute Superficiall particles of the body that reflects it to the Eye. Tis therefore a Passion of Light, rather than a Quality of body; Hence it follows

1. that White and black (formerly accounted the 2 Extream Colours) are indeed no Colours at all, for

1. White is but light reflected Undiversifyed from Polite superficiall [Globules], as wee see in froth which is white whatever be the Colour of the Liquor for Every little bubble (a multitude of which makes froth) gives its Vivid reflection (or stell) from one point as all Globular Polites doe; these Stells being thick set togather appear to the Eye as one plain light, for that the darke [spaces] between the Stells do not appear unless by near approach of the Eye.

2. Black is but a privation of lights reflection; for if the Superficiall parts be accuminated (or Sharp) they drink in the rayes between them, and reflect them not at all. Thus we see any hole in the door appears black to the Eye; and Windows at a distance shew darker than the rest of the wall in which they are placed, because they drink in many of the rayes whereas the wall reflects them. Other Instances are given of Plush; Hair of [a] Dogs neck brisled up; Standing Corn in the feild Waved by the wind etc: All which reflect light or appear dark according as the flat Sides or sharp Ends are turned towards the Eye. [73] Black Horn appearing White in its Shavings, and the Change of Colour in Liquors by Certain Mixtures is done only by Altering the figures or position of the particles

Colour is Light diversifyed; Black, White,
Are none; 'tis, or 'tis not Reflected Light.

2. That all true Colours are from Reflecting, and refracting Particles therefore the body Coloured must have Somthing of Diaphainety (or Transparence) in the Superficiall parts or there Could be no refraction; Hence Die-Stuffs are of Salts, or Christalline parts, which the more polite they are the more vivid and Glossy are the Coloures; because more rayes of Light diversifyed are returned to the Eye. Nor Let any think it Strainge that the Superficiall parts of an Opaque body Should be diaphinous; for

though they Appear not So to the Naked Eye, yet the Microscope will plainly discover them to be such, if you veiw them in the bright Sunshine. Now that Refractions, and Reflections make Colours is Manifest by the Prisme or Long Trigonall Glass which in Certain positions (Cross the Nose) Gives all the Colours of the Rainbow; and So Likewise Cut diamonds, and other transparent Stones from their Angular figures; Of all which se[e] Mr Boill of Colours who Gives the best account of this Matter that I Know. Therfore these Salts of Diestuffs (before Mentioned) Either are themselves figured to Give Such Diversifications of light, and then are Lodged in the pores of the Dyed body; Or Else they So alter the Superficiall parts of the body Its self as to fitt [them] for such Diversifying. And Alume is Usually added to Supply the defects of Glossines and vivid reflections.

3. There are but few Primary or Simple Colours, and others are made by their Mixtures. thus Purple is made out of red and blue; Green of Yellow, and blue, etc: And Indeed 'tis a pleasent Sight in a Microscope to descern the Distinct Graines of blue and Yellow powders Interspersed, when through the Instrument no Green at all will appear; Whereas If you Look with the Naked Eye upon the well mixed Powders you will see only Green, and no blue, or Yellow at all. And Hence it is that Green stuff or Cloath, will stain blue, by Urine or Other Acids, because the Yellow particles that Stick not So fast as the blue are by them [easily] removed. And Hence also blue Hangings, Gilded (as it were) with yellow Candle-Light alwayes appear Green. But why Yellow appears whitish by Candle-Light is a Matter to be further Enquired [of].

Refracting, and Reflecting parts give true,
and Vivid Colours, Primaries are few.

4. No Body has Colour as an Inhærent Quality therein but only as a Disposition thereunto in the figures and Positures of the parts, apt So, or So to diversify Light when it comes upon them. Hence there is no Colour in the Dark, or on the Inside of the Stick of Wax which is not red untill it be broken, and yeilds a Superficies to the Light.

5. Light may be tinged in transparency, as we may See in Coloured Glass thin China etc: because in the Passage tis diversifyed after the Same manner that it is from the Surface of other bodyes.

Colour is not Inhærent Quality.
Light may be tinged in transparency.

6. Polite bodyes reflect figure, and Colour. Whereas rough ones do

only Light. because Light will return any way more Easyly than the Diversifications, and Limitations thereof. And this may help to Solve the Appearance of figures and Colours by an Object Glass, at the Hole of a dark Room, for the Glass Colects the modifyed, and Limited reflections of Light, and transmits them to the paper where they are distinctly Seen; because all the Light that Comes in the Glass is So regulated: But if the Paper be removed out of its due distance, both Colour and Figure Vanish; because then the Regularity, or Lymitation is Disturbed; or if a Greater Light be Let in other Wise than through the Glass, the Light coming in Irregular mingles with the other and Spoils its regularity.

7. The old Distinction of Real, and Apparent Colours is [vain] for all Colours are alike reall or apparent, the Red in the Rainbow is as reall as the red in the Scarlet Cloth; both being but the Same kind of Modification of the Same Light.

Figure, and Colour by Polites are done
Reall, apparent Colours are but one

8. Lastly: Add to all this that though it be past all doubt that Colour is made by regular reflections [of light] yet the distinct rule of reflection, and refraction proper to Each Colour is not yet determined, Mr Boile himself recommends it, as a Matter of further Contemplation by the help of the Trigonal Glass before mentioned. And thus much of Light, and Colour the Visible objects of Sight

tho Colour be not what 'twas said (be sure)
yet Shewn by Light it Self remaines obscure

3. The Mean (or Medium) carrying the Object (or Visible species) to the Organ (or Eye) must be alwayes Somthing perspicuous, as Air, Water, Glass, etc: of this observe 3 things [74]

1. If The Medium be Single, or of Equall density, then the Object appears in the Same place and after the Same fassion.

2. But if it be double or Multiplyed; as Aire, and Glass; Aire, and Water, etc: then there is refraction; that is the Ray is Bowed, and this is after a twofold Sort.

1. Towards the Axis (or Middle Line of the Optick Cone) If the first medium be thin, and the Latter thick.

2. But If (on the Contrary) the first be thick, and the other thinn then the Refraction is from the Axis.

3. If the Surface of one of the Mediums be Convex or Concave the Refraction is also varyed according to the Rules of opticks; Where all the Nature of reflections, and Refractions are fully treated [of].

One Meane Presents a thing Just as it is
If Double, Convex, Concave varyed tis.

4. The Manner of Seeing (not as it Seams to be) by Extramission or Sending forth Rayes, or Spirits from the Eye to the Object; for the Eye is not Powerfull enough to Send out as far as [the] Eight[h] Sphere, or to the fixed Stars, and So far we can see; But by Introreception (or receiving inwards) of Lightsom rayes, Sent Originally (as from Luminous bodyes) or Reflected (as from all others) into the Eye. Therefore directing the Sight to the thing to be perceived, is but putting the Window or Pupill of the Eye directly against the Object so as to receive in its Species, to be depicted on the Retina (or bottome Coate of the Eye) whereby the Parts of the Optick Nerve are So moved, Pressed, or Affected as to Convey the Sentiment into the part of the Brain where the Common Sence is Lodged.

Intro-reception doth the Species bring
Where Nerve in Retina perceives the thing.

This doctrine of intromission Militates with that Conceit of Fascination (or Witch-Craft) by Looking upon with an Evill Eye, According to the Vulgar tradition, yet with all it must be Granted that as the whole body is Perspirable, So the Eye may have its Emissions for Some Small distance, but whether So as to affect another body, I much doubt. Wee may indeed be terryfyed with a fierce Look, and Refreshed with a Gracious, and favourable one, etc: But this Seams to be rather by Ratiocination about the Person who Shews Such a Countenance than by any Steams which proceed from the Eye. Tis as if one should say to himself; that Person looks fiercely, therefore he will hurt me etc: Certain it is that a Passion Changes the Eye, but not the beholder of that Eye, Unless by Humane Sympathy or Reason about the Consequence of that Passion.[1]

Fierce Looks do terrour strike Love, Greif in Eye
Work Like by Reason, or by Sympathy.

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[1] This brief rejection of the belief in the evil eye has considerable interest because of Morton's quiescent part in the Salem witchcraft proceedings of 1692. Thomas Brattle wrote that some of the Salem justices undertook to explain the cure of afflicted persons by the touch of their supposed tormentors on the basis of Cartesian philosophy and the doctrine of effluvia: ". . . and the account they give of it is this; that by this touch, the venemous and malignant particles, that were ejected from the eye, do, by this means, return to the body whence they came, and so leave the afflicted persons pure and whole." *Narratives of the Witchcraft Cases*, George L. Burr, Editor, p. 171. Neither Brattle nor Morton held this opinion, nor did Increase Mather, who wrote that "the notion of Fascination by the Eye is unphilosophical." Increase Mather, *Cases of Conscience Concerning Evil Spirits Personating Men* (Boston, 1693 [1692]), p. 42.

5. The Dignity of this Sence beyond the Rest, is in diverse respects, but in two Especially; Finess of Species, and Matter of Reason.

1. Its Species, (If I may so Call them) have a nearer approach to the Spirituall nature, and Active motion of the Soul; for we see allmost as soon as we think, in a moment, and at a Great distance, and that by Rayes of the Most tenuious matter; whereas all other Senses require Grosser matter nearer approach, and Longer time to perceive.

2. It also affords matter of more Rationall Contemplation; the Visible things of the Aspectible world lead us to acknowledge, and Meditate upon the Invisible things of God. 'Tis also Dignifyed with a Mathematicall Science, Namly opticks which is dependent on Sight, and is Subservient thereunto. And So Much for this first Exterior Sence of Seeing.

Sight to the Soul doth bear a Near Relation
More Matter dos afford for Contemplation

Chapter 24

Of Hearing

HEARING is an Exterior Sense Perceiving Sound by the help of the Eare, which is a Part of the body made up of Cavity, Membranes, Bones, and Nerves.[1] All Discribed in Anatomy, though here a Little of them. The Ears parts are Exterior, and Interior.

1. Exterior, Figured for Beauty, and Use.

1. The Beauty, and Repute of it is manifest in the Cropping of it, as a juditiall [75] note of Infamy.

2. The Use of it is to prepare the moved, and Sounding air for its Circumvolution in the Inner parts; yea the Lobe which seams to be of little use yet is taken Speciall notice [of] by Physitians in a near approach to death, for its Coldness intimates a drawing on. And also by such as Deal in Clothes, who feal it with one hand while the other feals the Cloth; and So by comparing give an Estimate of the fineness.

Organ of hearing is the Eare Abstruse
Whose outer parts for beauty and for use

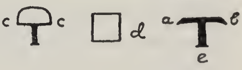
2. The Interior parts are Coclear, Drum, Stirrup, hammer, etc:

1. Coclear, Revolution in the hole that goeth in through the Scull winding about like the inside of a Snail shell, whence it has its name.

2. The Drum, a fine membrane which is spread overthwart the hole.

3. The Stirrup, (or Staple) from its figure is a little bone joyned to the membrane.

4. The Hammer a Little bone like the [Roman] Letter T. whose ends (a.b.) move in the Holes of the Staple (c.c.) and the End (e.) rising and falling at every Shake of the Drum beats upon



5. The Anvill (d.) a Little bone Set under the hammer, whereon is (as it ware) formed every particular Sound.

6. Then there is a Cavity filled with Internal Air which is affected, and moved, by the Severall Knocks of the Hammer.

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[1] Aristotle's brief treatise *De Audibilibus* supplements the *De Anima* and the *De Sensu* as the background for Morton's acoustics. This chapter, too, is closely related, although not perhaps indebted, to Francis Bacon's extensive experiments and discussions of sound in the *Sylva Sylvarum*, Centuries II and III.

7. Lastly, the Auditory nerve expatiating itself (Like the Optick nerve in the Retina) is moved and affected by this internall Air, and So Derivation is made by the Vibration thereof, to that part of the Braine, where recides the Common sence.

To Hearing Coclear, Drum, and Stirrup Serve
With Hammer, Anvill, Cavity, Air, and Nerve

2. The Object; Sound, distinguished into direct, and reflex.

1. Direct Sound was Antiently defined, a Quality arising from the Collition (or smiting togather) of two Solid bodyes; By Solid they Understood Such as were formally, or else Such as were Equivalently So. By Equivalents may be understood Less Solids Swiftly moved. Such as air and [a] Rod Struck Swiftly through it, which makes a Quip; then this Impelled air was Supposed to move the next, and that the next untill it arive to the Sensory. But Latter men do otherwise conceive it; namly that this which is called a Quality is no other than a Vibration, or Shaking of the Air in which must be considered [the first] I[m]pression and [the] Continuation.

1. The first Impression and this either by air upon air or Solid upon Air.

1. Air upon Air is manifest in the bounce of a Gun, or thunder, in these the Inflamed matter Expatiating itself Suddainly forces the Air at the mouth of the Gun, (or parting of the Clouds) to part Suddainly, and (as it were) to Start back; then when it can, it rushes [as soon] togather again, to avoid a Vacuum, and So one side beats against another, which causes a Shake and [that] is communicated to the Ear. Now this Starting back and returning againe and indeed all the Vibration is from the Airs Elasticity (or Springiness) of which before, see also Mr boile on that Subject.[1]

2. Solid upon Air is when the Solid is Vibrated, and thereby puts the Adjacent Air into the Same Vibration; and this is best Performed by Springing things (as Bell-Mettall, Brass, Glass, and Some woods more than others, as [Deal] of which the [Bellyes] of [Musicall] Instruments are therefore made, Ash, Maple, etc:) and this Seams to be the reason of the Sound of an Hammer upon a table; for a Hammer if it be Struck on [the] table, and Especially if it rebound off again causes all the parts of a table to vibrate, and smite the Air, but if the Motion of the hammer be Slow (though Strong) or if it be Stayed on the table when [it is] at it then there being little or no vibration the Sound is accordingly.

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[1] The reference is to Boyle's *Spring and Weight of the Air*, to which, as Mr. Morison has said, Morton owes much in this chapter.

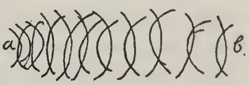
Sound Hearing's Object, by Vibration
Of Air, on Air, Solid on Air, is done.

2. The Continuation of this impression through the Air is (Sir Samuel Morland)[1] by Undulation and So is Supposed to Come home [wavy] ∿∿ to the Ear Even as we see in Water, if a Stone be dropt into the midst of a Pond it will Cause many rings of Waves one Still begetting another every way, till the motion of the Water come out to the very banck. The reason of which is that the Water removed by the Stone thrusts up the next in a heap, because it has not room behind it to give way; but then when it is risen in a height answerable to the force of the Im-[76]pression, its own Gravity Causes it to fall down again, and Crush the next, and so beget another wave, that another, and So on, as Long as the motion first impressed doth last: Hence it is that the waves are higher and the thickness (or Horizontall Dimention) is Less near the first Impression, but Lower and broader as they goe farther off. Now as the water gives way, and waves by the Violence of a Push (or blow) So dos the air also when it is Smitten; though in less undulations (or Waves) because its body is more tenuious, and sooner gives way And hereby the way of the motion is lengthened, more than a motion in the right line would be; and therefore at Some distance we See the Stroake before we hear the Sound.

By violence in water waves are found,
Like undulations are in Air for sound

2. Reflex Sound is cal'd Echo. Which requires to its Constitution besides a Sound given 3 things. Hollow body, thick Air, and Due Position

1. An Opposite hollow body, Solid and (best is) Somwhat vibrating, that So the appulses of the Undulations may be turned back again as we see in Water; the Undulations beginning at the place of the Stones falling (a.) by degrees waves out as far as the bank (b.) but here it begins to wave back again towards (a.) from whence the waves first came; So it is



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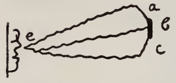
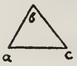
[1] As Mr. Morison has noted, Morton's whole chapter owes much to Sir Samuel Morland (1625–1695), *An Account of the Speaking Trumpet* (London, 1672). This study, which was also printed in the *Philosophical Transactions*, No. 79, includes a discussion of the nature of sound. As Mr. Morison recalls in his foreword, Samuel Wesley was particularly shocked because some of his schoolmates at Morton's academy shouted insults through a speaking trumpet at the local Anglican clergyman. In 1678, by the way, Increase Mather appears to have been interested in Morland's speaking trumpet. See Kenneth B. Murdock, *Increase Mather*, p. 147.

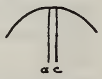
in [the] Sound for oft times one hears his own voyce, and distinctly the last of his words, and tho a plain flat may return Sounds yet tis best done in a Hollow; for herein diverse Echos are collected and broght to the Same Ear; as from (a.b.c.) 3 sides of a Cavity. 3 returns are made to the Ear (e.) whereas from the single plain (b) there can be (according to what is said above) but one Single return towards (e.) Hence it is that Hallow Empty Cask[s] Sound Notably by a Multiplication of Echoes for the reflection is from all Sides to the Center where the moved air again meats, and So begets a new Con[c]ussion or Multiplication of Sound which issues out togather at the hole (or bung.) It must also be (for well to do) a Springy Solid that may Cause the Air to rebound, and thereby the better to Continue its motion Hence firr, and Ash if fully dry (as is before noted) are best for musicall instruments; and a Room Winescoted [is] better to play in than one with hangings which will Quell and dead the Vibration. A fire Also in a Room Spoyles Sound for that it draws the Air to it, and returns it not unless in another motion Sutable to its own nature, namly to heat and not to Sound, hence also it is that a room new plaistered, washed, or Whited Gives the best Echo because the moisture for present fills all the little holes or Crevices which else would drink away the Sound and So Likewise dos open Casements Doors, and Chimneys.



Echo from hollow, Solid, Springs abound
Where Care is had that nought drink off the sound

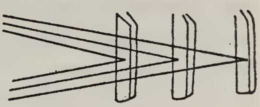
2. It requires also a Moyst, and thicker Air, and this Quiet and undisturbed that the Undulations may be kept better distinct, and togather and may have some Sensible difference between the direct and reflex Sounds; hence therefore the best Echoes are heard from over a river, or in a Still evening when there is a Moist and Quiet Air.

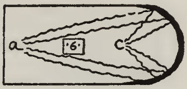




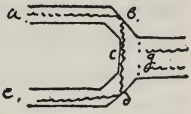
3. The Positure of the Ear Must be such as that the Angle of Reflection being the Same with that of incidence may bring the Sound directly to it. So if (a.) gives the Sound it Smites at (b.) and is returned to the ear (c.) which now hears the Sound two wayes, the one by the line (a.c.) the other by the reflecting line (a.b.c.) but then the person who gives the Sound at (a) hears not the Echo of his own Sound If he would therefore hear it he must So Alter the place of his Standing to be at, or near perpendicular to the reflecting Cavern and then the Speaker at (a.) and the Hearer at (c.) will be both togather as in the Diagram. Hence the Multiplication of Echoes is when there are more reflecters Standing in the Same angles; Such are the [But-

tresses] of a building, (as in the Diagram) the Clefts of a Rock, etc: And [77] here the farthest Echo comes last, and faintest home, but if the reflection be Equidistant then the Echoes will come home altogather, and be more loud and distinct. I have heard that Sir Peter Ball near Exeter, built a Musick room of an ovall [form] both top and end, and this over a pond to keep the Air thick which had an opening in the Middle of the floor represented by the Little Square (b.) the Players to Stand at (a.) and the principle hearer at, or near (c.) the focus of the round Cavity, and where all the reflections will return and meat upon him.[1]





Nothing Sets forth the truth of this of the Angles of Incidence and reflections in Sounds better than the famed Whispering place at Glosester which I have Seen, and observed.[2] Tis an Arched passage part of an Octangular Leading about the East End of the Cathedriall Quire; wherein the Whisper at (a.) Sends forth a Small Sound to the outer wall (b.) thence it's reflected to the Inner wall (c.) thence to the outer wall (d.) and thence [tis] cast at last to the hearers Ear (e.) Yea though there be a great opening into a Chappell at (g.) yet this draws not off the Sound because it Strikes not there but at the Inner wall (c.) which is over against [it], and if a third man Stand at the open place (g.) or at any other place out of the Line of the Whispers [Course he hears not the Sound,] and yet at (e.) which is farthest off it's heard distinctly.



Through air thick, Quiet, Moist, are undefac'd
Echoes return'd to an Ear rightly plac'd.

2. A Second Distinction of Sound May be as to time Short, or Continued.

1. Short as a Knock, bounce, Quip, etc: when the impuls to the Air, and the appuls to the Ear is but one

2. Continued as a roar, or ting of a bell, Sound of a String Stricken, blast of a Trumpet etc: this is but the other multiplied, the Stroakes So Close and thick set togather that the hammer of the Ear cannot fall down on the Anvill, after one before comes another Stroake home, this may be perceived in the difference between the common beating and Rolling (as

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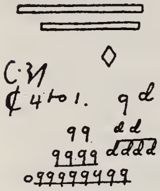
[1] This music room was presumably at Mamhead, the Ball mansion near Exeter, but the editor has been unable to discover any other description of it.

[2] A long description of the whispering place at Gloucester was read before the Royal Society on November 5, 1662. See Birch, *History of the Royal Society*, I. 120–123.

it's Cal'd) on a Drum and in a Musical String, or Ring of a bell, tis but a multitude of Quips each one made by Each Vibration. from this [Continuance] arises the Eight measures of notes in Musick, Large, Long, Breife, Semi-briefe, Minim: Cratchet, Quaver, and Semiquaver, and their derivatives, triple and quadruple.

> Short Sound by one Appuls is Specify'd
> Continu'd is by the same multiply'd.



3. A third Distinction, as to Loudness, is Strong and weak.

1. Strong, which Undulates far, beats much air, and mounts the Ear hammer Extraordinary high: this may Somtimes excell and hurt the Organ; Such are the bounce of a Cannon to one that is nigh; the noise of Bells ringing to one that is in the Steeple among them [etc:]; this commonly makes deaf for a Little time after (as Looking directly on the Suns body makes blind for a While,) because the tention (or Stretching) of the Drum is Such that it cannot presently reduce itself to its ordinary stretch. Yea I know [an Aufe] ([or] Naturall fool) Said to be made So from the Suddain [and] unexpected Sound of a drum, and as it is disproportionable to mans Spirit, So it is also to food that Should maintain them; for Experience Shews that Thunder, Great Guns; etc: (as is before noted in the Chapter of thunder) do Spoile Bear, Milk, etc: The reason may be their Concussion of the Air So briskly as that it is communicated to the Small particles of the Liquor, So as either to advance their Sediments, before dismissed by fermentation or to alter the Site and figure of the Component parts that they cannot equally (as before) maintain their motion, or retain their Spirits A Traditionall prevention of this is the Laying a bar of Iron over the Vessell which if true, the reason may be guessed that partly by weight it Stops the vibration of the vessel, and then perhaps a rope tyed about it or a Stone Layed upon it would do as well, and partly by its Springy nature common to mettal receiving the vibration into its self, that would otherwise invade the Vessell, and then any other ringing matter would be its substitute; though this is most usuall because next at hand. But as there is Somtimes hurt So there is Good also comes by these great Sounds. It Sends in Shoales [78] of fish to Some Shores, whereby Men the better get them: It Everywhere purges the Air, probably by precipitation (or throwing down the Noxious vapours that hang in it;) and therefore it may be profitable to Shoot of Store of Guns, and Lustyly ring bells in times, and places of Contagion.

2. Weak, and Soft (on the Contrary) beates little air, and undulates but a little way; therefore is Scarce audible by Scarcely moving the hammer of the Ear; Such are [whisper], and any Sound at a Great distance.

Strong Sounds do good or ill effects produce
Weak do no hurt, and are of little use

4. A fourth distinction of Sounds is as to tone arising from the Number of vibrations, or returns in the Same time, and So [they] are Low, or high.

1. Low, Base, or Grave, wherein the Vibrations are fewer in a certain space of time this is perceivable in a Womans Spinning-Wheele, which if whirled Swifter gives a Shriller Sound; but as the Swiftness abates, So the Sound fals; also in Boyes Casting on Huming tops, which Sound Shrill at first, and after fall by degrees. In Strings of Instruments this Variety arises, from the Length thickness, and tension; and that Singly or Conjoyned; for the Longer a String is it vibrates the Seldomer; because it hath farther way to go [ere] it returns; the Slacker also for the Same reason, and also because its Springy parts whereby it should be accellerated are (as it ware) Let down. The thicker Strings are Slower; because the Greater impediment from the air.

2. High, Trebble, Sharpe, or accute Sounds, are from Contrary Causes producing Contrary Effects. Here therefore the Strings must be Short, Small, and Stiffly wound up. now all this is gathered from the Swayes of pendulums wherein the Shorter Strings make Swifter returns of the bullet; and yet all its returns from first to Last are (at least Sensibly) of equal time So it is in the String of an instrument; for if it be drawn sidewayes an Inch from its streight line, and then let fly it yeilds the Same tone as it dos when it is almost Quiet; because though it be Swifter when it is first let go yet its returns are in the Same Sensable time, as when it moves never so little. The difference will be only in Loudness; for then when it moves swiftly it beats more air, whereby Sounds are multiplied, and thereby Magnifyed; as a Vally of Shot Sounds farther than a Single one, and yet the beating of So much as it Strikes is all after the Same manner.

On this Diversity of high, and low tones are Grounded all the doctrine of concords and Discords in musick, of which in the next Distinction. And by this also may be understood what is number of Sounds which is Said to be the object of musick for it is no other than the [proper] number of vibrations in every tone or Sound; and the proportions that are between them answerable to the proportion[s] that are in Arithmeticall number.

Vibrations Number Sounds of Low, high, Chords
by thickness, tension, Length of String affords

5. Distinction of Sound is pleasing and unpleasing, according to the apt proportion it bears to the motion of our Animall Spirits. This is either Physicall or Mathematecall.

1. Physical when it's Clear, Smart, etc: depending on the Qualification of the Singers throat, or Players instrument whence the Sound proceeds. And this Sound is Somway delightfull [even to] brutes, as the wild notes of birds to those of their own Kind; the Gingle of bells and Sound of trumpets to horses, and So of others.

2. Mathematical when the Sounds are proportionall Each to other, and have apt place or Consecution in a Musicall tune.

Of Musick the Theory is a Science; the practicall Use in Voyce or Instrument is an art, the Proportions are found out by the divisions of a Monachard (or Single String) for as the length of any part is to the whole length So will the Sound of the whole and part be one towards another.[1] Hence tis found that 2 strings of the Same Length, thickness, and tension will yeild exactly the Same Sound, or tone, and if one be Struck the other will Shake, these are Called Unisons, and are Harmoneous but where there is difference in [these] Circumstances (unless one Compensates the other) the tones will be different, and that either Concord, or Discord.

1. Concord are Such as vibrate So as that there is an exact conjunction in the points of [time] wherein they make their returns, and if the Conjunction be on both sides of the vibration tis call'd a perfect concord, if only on the one [79] side tis an Imperfect one. These Concords help the motion one of another, because the Undulations of the Air Smitten are (as it ware) one and the Same way.

2. Discords are when the Vibrations of the Severall Strings do So cross, and Interfere that they never turn togather, these hinder and extinguish each others motion, because their Undulations being travers do interrupt and confound one another, and So neither of them can come Distinctly or Smoothly to the Ear.

All these concords and Discords are comprehended within the compass of 8 notes Inclusive, for there are but 7 Specifically distinct tones in nature, the 8th being a Kind of Unison to the first, and is Cal'd Diapason.

This is manifest in a Whistle, wherein if you breath Gently it gives the Slower vibrations, and the Lower note: But if you blow Stronger (in the Same Stop) you Immediatly pass into an 8th above: and So dos a Bull in roaring even to 2 or 3 8ths Successively. The Reason is because the length, or bigness of the Instrument on [that] Particular Stop, is only fitted for one kind of note, either by Single or Double vibrations, but if you Stop one or more holes you thereby Shorten the Instrument, and then will another note arise by a soft [breath], and its 8th by a Stronger blast.

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[1] Morton's introduction to music is not very helpful, for he appears to be in error both in his description of concord and in his scale of musical notes. See, for a convenient view of the musical knowledge upon which Morton could draw, Thomas Morley, *A Plaine and Easie Introduction to Practicall Musicke* (London, 1597), pp. 2, 70–71, etc. Although Morton mentions the monochord, he appears to be ignorant of the discovery that strings vibrate in segments, communicated by John Wallis in the *Philosophical Transactions*, No. 134 (April 23, 1677).

So then the perfect Concords are Unisons, [or] 8ths 3ds and 5ths. The Imperfect concords are 4ths and 6ths and the discords are 2ds and 7ths the Same is Said of their Compounds, their 8ths above, or below; for these are (as was Said) but the Same Notes repeated again in a $\left\{\begin{matrix}\text{higher}\\ \text{Lower}\end{matrix}\right\}$ Key The Scale of these Musicall notes is Gam-ut, A-re, B-mi, etc. Artificial names given to every musicall tone; these in Singing are Shortened to Sol, La, [Mi], fa, [Sol], La, [fa]; the proportion of them one to the other is measured by arithmeticall proportions; So 8ths are Double, 5ths are trebble, etc: as may be Seen in the musicall Scale of proportions. It's wonderfull to consider that the same proportions of Length[s], and breadth[s] to Sight are harmonicall, and pleasing to the Eye, which in Sounds are delightfull to the Ear, So that a man may build a house Musically for if the Dimensions of parts be according to the Scale of musicall concords, and their proportions it will be pleasing to the Eye, But if the Dimensions vary never So little from these proportions, 'tis Uncomly, Inharmonicall, and Like an Instrument out of tune to the Eare; Every ordinary beholder will say it is not very handsome, though he knows not why. This is a notion worthy to be better considered by Archytects, Especially by Gardners, Cabinet-makers, Silver-Smiths etc: and all whose works are [properly] Eye-Objects, and design'd for its delight; for hereby Shall they Set off their work more Acceptably, and to the Universall Content of Mankind.

What in the Ear's delightfull Harmony,
the Same proportion's pleasing to the Eye.

The Mathematicall pleasure of Sound, is peculiar to man, and common to all men, So that Harmony, and Discord are perceived by the most Savage persons with resentment. Whereas brutes may Love the noyse but have no regard to the Harmony; the Reason of this can be no other than [an] Agreableness of the Musicall airs motion with that of the Spirits in humane bodyes: Add to this a Rationall aptitude in man to approve of Entire, orderly, and Equall parts, more than broaken uneven and Confused, as it please a man [more] to See a whole, and just a half (answerable to an 8th in Sounds) than a whole and Somwhat more or less than [an] halfe So 2 and 3 Answerable to a 5th in concords, than 2 and 3 with an Irrational bitt over, or under. for Such an Object perplexes, and dos not Satisfie the mind. Now Seeing there is Such an Agreement between the Eye and the Ear (as is before noted) the Same is the reason of Sounds in all other concords, and yet it must be confessed there are Some men have less regard to harmony in Eye, or Ear, than others tis Supposed they will not boast of it as their perfection. Some are also more pleased with the Sound than with the proportion, therefor the briskness of a trumpet or the [Squeale] of a Violin Soundly Rubb'd to make a noyse dos affect them more than the best compositions of Viol Consorts, but that is because they are more Sensuall than Rationall. This Last mentioned Inclination is a Little too near the brute: but of those that are Musically inclined there is a variety as to the modes; Some are for the brisk Corants, Others for the Grave Almaines, and the Like; And So as to Eye-objects, Some like the Comly shape of an house, or habit, others the Garish ornament [thereof] from the one or other prevailing, or a decent mixture of both, may be attain'd a reasonable guess at the Naturall abilities or morall **[80]** Inclination of Persons. I have heard that a Great Person being Entertain'd with musick upon a very Solemn occasion, the Composer beforehand by Enquiery, got knowledge of Some little tunes that the Prince was want to Sing to himself, as a Naturall, Solitary Entertainment; and then adapting his Compositions to the Same Key, and mode; he made them more than ordinary pleasing. A Good Archytect, being also a Good Mathematicall Musitian Might (I [think]) from the pleasing musick of any person upon the Same Grounds before mentioned contrive for him a very delightfull Structure. But herein I would advise that the design Should be accomodated to the probable inclinations of his more composed years, though the work may be done in his youth; because the house remaining the Same, and his age varying it had need be fitted for Such time as he May Most Enjoy it, and not blame himself or [his] Archyte[c]t for former folly. And this much for the pleasure of Sound.

2. The Unpleasant or Uneligant Sound (by Consequence) is that which causeth a Motion of Air unsutable to the motion of our Spirits; Mathematically Such as discords in Musick, Strings out of [tune]; or Physically, Such as Shreikes of filings, or Scraping of trenchers, etc: which do (as we express it) Set our teeth on Edge. That is disorder the motion of our Spirits, So as the tender nerves do trublesomly feel it. I have been the Longer here on Sounds to prepare a way for the better understanding of

that difficult Mathematick, the Theory of Musick, with which few Scholars are well accuainted.

Naturall Sound that's Smooth may please a Brute
But artificiall only man dos Suit.

3. The means of transferring [this] Motion from the Object visible, to the Organ, Ear, is ordinarily [the] Air; but it may be ob[s]curely conveyed through water, or by a Long peice of wood or timber, and not only the Ear, but the teeth [also] may receive the Vibrations, and their harmonicall proportions, as was manifest in a Deaf and Dumb man whome I have Seen pleased with musick by holding the Halft of a Knife in his teeth whose point was Stuck in the belly of a Harpsicall; But this perhaps may be rather cal'd a feeling a Motion than hearing a Sound, however from hence it appears that even to [that] Sence proportion is a delight, and probably tis to all the rest.

Air is the ordinary mean of Sound
Its Substitute is ought that will Rebound

Chapter 25

Of Smelling, Tast, and Touch

SMELLING is the next Sence in order; because tis at Some distance, as the other two are, whereas the two latter, tast, and touch, are by Immediate Contact: and besides the matter, or Species in Smelling is more tenuious, and fine, than that of tast, and touch.[1]

Tis defin'd an outward Sense perceiving Scent or Odours by the help of the Mamillary processes or duggs of the brain; for towards Each nostrill is a protuberance of the brain like a dugg, or teate, before which Stands a part of the Scull perforated with many little holes, and therefore is Call'd Os Cribrosum, or the Seive bone.

The Object is any body that hath Effluviums, or Steams perceptible by this Sence, and herewith Some little moisture are those of the first Quallityes that Cheifly Contribute to Odours; for when a body is perfectly dry, there wants a Contrary to Cause fermentation which is necessary to the Exhalation of Steams. Chymists ascribe odours to the volatile Sulphur carrying with it Some volatile pungent Salts. The Effect[s], or Affections of it are pleasing, and profiting, or offence, [and] hurt to the brain. [And hence ariseth the Dignity of this Sense, in that tis So much concerned about the Cheif Seat of the Soul.

1. Pleasing and profiting, when the Steams are agreable to the Animall Spirits of the brain,] whereby they Seam to contribute to them a Recreation and nourishment. Yea I have read of one that was many dayes Sustained with the Smell of bread Sopt in Wine, and So the Steams became an Immediate kind of food; of this Kind are Amulets, Nodels, etc: Hitherto also referr the prelibation or foretast at a distance of Such foods as are agreable to their Stomacks, much used by brutes, either to try or find their food.

1. To find their food by hunting after it, Hence that homly proverb, (A Poor mans Sow needs a Good nose.) Thus hounds hunt hares, and Spaniells, Partriges, which they will eat while raw; but when altered by dressing from their Sutableness, by Smell they discern, and refuse their bones. As for the hunting of foxes, Wolves, etc: which they will not eat,

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[1] In this chapter, once more the background is Aristotelian, the *De Anima* and the *De Sensu* being in point. But with the older ideas Morton combines some seventeenth-century physiology. For comparison, see Legrand, *Institutio Philosophiae*, Pt. VIII, chs. xii–xiv, and Burton, *Anatomy of Melancholy*.

it Seams a Kind of Gallantry in [a] pursuit of an Enemy, or a Naturall delight in Exercising their Sagacious faculty.

2. To try or distinguish their food, this is observed especially in such brutes as have the roughest tongues; for that draws their food inwards, So as they cannot (Like a man) Spit it out if it dos not please their palate.

Brutes taught by Instinct Smell to find their food
and when they have it try if it be good. [**81**]

Besides this there are some Smells that irritate, and are a kind of Physick, they are not hurtfull yet not altogather agreable, and therefore cause Such a Small convulsion of the Coates of the brain as only Stirs them to Exclude that which is Excrementitious, and might be hurtfull if it were retained (much like the Galls pungency in the Guts which dos promote Excretion) of this nature are all Scents that provoke Sneezing (Said to be the Good Effect of a bad Cause) for hereby the Muddy Steams that occasion Sleepyness are dispelled. A Usfull consideration for Such as are apt to Sleep at Sermons.

To Please, and Profit are Scents best accord
which food, or Physick to the brain afford.

2. Hurtfull Scents are either pleasing or Offensive.

1. Pleasing Such as Poysonous perfumes, [and] the Miasmata or Infectious Steams, in Contagious deseases, these are Said to Slide in with a Sweetish Scent; and thereby insinuate themselves among the Spirits of the brain, and are pernicious to the animall. Besides Some Women Subje[c]t to fits of the Mother, or Uterine furours are Greatly hurt by Sweet, though wholsome Savours; for these affecting the Meninges (or Coates of the brain) move them so violently that they also affect the Womb (a Membranous part too) as to Cause it [to] rise out of its proper place, Now in this Cace the Cure is by Contraries, for all filthy Stinks Such as Assafœtida, bur[n]t feathers, etc: will set it right, and Quiet it again.

2. Offensive, and So most immediately, and Directly do Scent[s] hurt; as the Smell of Carrions, Ditches, fenns, and other Putrid matters which Cause hed-aches, Sickness of the Stomack, etc: Hitherto also may be referred the percellence, or Excess of Odours, [which] is very offensive; As the [Civet] Cat's room, Sassafras wood in Jamaica Rosmary in Spaine, or any too Strong perfumes for there is a certain measure of Scent Sutable to every animall; as Sweet herbs, and Some flowers to man which Swine or Neats regard not, yea horses refuse to feed on them; whence we may Gather that Everything hath its proper texture of parts, and therefore its conveniencyes with the like varyety.

Hurt Comes by treach'rous Steams Stinks that offend,
and Sweets that do beyond the mean extend.

There is no Science concerning Smell nor of the two Senses that follow as there are of the foregoing two (namly opticks, and Musick) yet there are [arts] belonging to them all, to prepare things Sutable to Each. to this in particular of [Smell] is the Art of perfuming which Consists in Apt mixtures of Odoriferous bodyes; as of flowers, Herbs [certain] Woods, and their Extracts, the Most notable purfume is Musk and Zibet, ([or] Civet) mingled togather in due proportion for togather they do [well] but neither of them alone; the Reason is Said to be that one Volatilizes the other, and Causes it to diffuse its Odour which otherwise it would not doe

Perfuming's th' art of Smell, of which th' Intent,
Is by apt mixtures, to give pleasing scent.

And So much for Smell.

4. Tast this Sence is by Liquors as the [other] was by fume, tis an outward Sense perceiving Tasts, and Savours by the help of a Gustitory nerve, whose branches Spread in the tongue and Palate of the mouth. The Object of tast is tastable Quality (Say the Antients) or rather Some Saline parts mixed with moysture, which least it should [want] the tongue and mouth make a Supply from the Grandules or repositoryes of Spittle. Its Cheif use is to distinguish meats, and drinks, whether they will prove agreable to the Stomack which being a Membrane Continued with the Inside of the mouth by the throat or Swallow pipe is hereby moved, and affected So as by naturall appetite it inclines either to receive or reject according as the mouth is affected.

Dissolved Salt the tast in mouth perceives
Stomack forewarn'd by this apt [food] receives.

This and the Next are accounted but Mean Senses because their objects are more Gross and must be immediatly applyed to the organ, whereas all the former do admitt a distance: therefore to these is especially applyed the name of Sensuallity, in an Evill Sense as delighting in things, and after a manner common with brutes, yet has it this Excellency that it seams to conduce more to the life of the Animall than any of the rest; because its Subservient to the Stomack that must maintain all the members.

Tast is but mean its Object must be nigh,
Yet th' Animall preserves his life thereby.

Tasts [or] Sapours Distinctions are in respect [to the] Qualities or to the Sense.

1. In respect to the first Qualities, and So they are either hot, or Cold, or Moderate.

1. Hot, [as] Sharp; (Such as Pepper, and Ginger, etc:) Salt and bitter.

2. Cold, [as] Acid, (or Sowre) and austere, (or harsh as that of Green fruit.)

3. Moderate as Sweet. [82]

2. In Respect of the [Sense] of tast, and So tis either Extream or mean.

1. Extream which produce in the Sensory most contrary passions, as bitter and Sweet.

2. Mean or Mixt as all the rest.

Tast, hot, Cold, Mean, as to first Qualityes,
to tast Extream, and what between them lyes.

About this Sense is the Art of Cookery which Consists in Making wholsome Meats palatable; an honest Comfort as Conducing to the health of [man] but is abused by intemperance (of which in Ethicks.)

Cookery renders pleasing, wholsome food,
Intemperance abuses what is Good.

5. Touch this is the Meanest of all, because its object is [most] materiall. Tis an Exterior sence perceiving touchable Qualityes by the help of nerves diffused all over the body.

The Objects are tactile Qualityes, as the four first, Hot, Dry, Cold, Moist, and Some Seconds as Hard, Dense, heavy, figure, etc:

The Mean or Medium is the Upper Scarf-Skin to which the tops of the nerves do reach. Therefore the Degrees of this Sensation, is according to the finess of [that] Skin, and its Softness, thinness, and nearness to the nerves, hence Some parts perceive better than others, and not only feall but distinguish, and So this Sense becomes a Substitute for Sight in blindness, or darkness; the Parts Especially distinguishing are the tops of the fore fingers, which are So perhaps (besides the above Said Circumstances) for that the nerves proceed thence to the brain in a Streighter Line than in other parts.

Touch Qualityes 4 first, and diverss [Second],
Perceives through outer Skin its medium [reckond]

The Manner of this Sense Seams to be by a pressure or Vibration of the Nervous Spirits which they receive without in the Extremity, and

Carry back through the whole Course of the nerve. The Pleasures of this Sense we have else where shewn to be from a Sutable warmth, Softness, Moisture, friction, Titillation, etc: as in the Doctrine of delights. The adverse to it is pain, and that either [punction] or tension.

1. Punction (or Pricking) tis when the Dolorifique matter, (Such as Some Sharp humour, (or Salt) within or Externally Some Sharp pointed instrument) in a Small part of the body attemts or performs a [Solution] of Continuity or undue Seperation of parts, Cuting Seams to be but this multiplyed, or Extended to more minute parts, for that a multitude of Physicall points will make a Physicall line, which is the Only difference between a Sharp point and an Edge.

2. Tension (or Stretching) is when Some humour, or Vapour, by [the] Expatiating itself in a Membraneous Cavity, threattens, and attempts the like Solution (or tearing assunder) which if it can Effect (where it may be done) the Sharpness of the pain Ends as in the breaking of a boyle or Impostumation, Such pains are Chollick, Hed-ache, Stopping of Urin, etc:

Pressure of nerves is pleasing when tis mean,
but otherwise bring[s] priking, Stretching, pain.

The Privation of touch is numbness the Usuall Symptome of a palsey. Which because Somtimes its without hurting the motion, gives occasion for Some late anatomists to assert that the nerves of Sense are different from those of motion but others Say tis [Still] the Same nerve, though otherwise affected namly by the beginning of Vibration, for in motion it proceeds from the Root to the branches, whereas in sense tis from the branches to the rootes.

Motion, and Sence from Several nerves do flow
or the Vibration Severall wayes do goe.

The Sense of touch though it be sed to be the meanest, yet has it Some peculiar dignityes: for whereas all other Senses principally serve the Individuall this hath no Small Concurrance to the Conservation of the Species.

Hence old Sarahs womb was Said to be in deadness when it was in many degrees deprived of this Sense. The Necessity of it in Nature is seen in that it is rarely, (if ever) wholly wanting in an Animall. Whereas any of the other Senses often are. This can be a Substitute for Some of them, but none of them can supply the place of this. Lastly the Extension of it is to all the Parts of the body in Generall, others are confined to their particular organs; and this hath given occasion to latter men to pronounce that all

Sensation is by touch, and that the other particular Senses are but the Species of this, and So much for the Exterior Senses.

Touch Serves the Senses; Never wholly is
Depriv'd; Supplyes for others: all have this **[83]**

Chapter 26

Of Interior Senses

INTERIOR Sense (So Cal'd) is Said to have its Seat only within the brain, tis 3 fold Common Sense, Fhantacy, and memory.[1]

1. Common sense, a Power of the Animall Soul whereby it Judges of the object[s] of Exterior senses, and descerns between them; its Seat is Said to be in the forepart of the head, because there all the Sensitive nerves do meet of this Consider the Objects and [the] Acts.

1. The Object, Every Sensable, Sensated (or perceived) by the Exterior Senses, as also the Acts of those Exterior Senses, which because they cant reflect on themselves therefore they need a Superior power to do it for them.

2. The Acts which are Said to be twofold, Direct, and reflex.

1. Direct, which [act] upon the Sensible object, tis 3 fold, Apprehension, Dijudication, and Discretion.

1. Apprehension of Sensible objects.

2. Dijudication of them, that So there may be

3. Discretion, Discrimination or discerning between them which act is either positive or negative.

1. Positive, which is comparing two objects discerned apart by their positive Essences as when we think by the judgment of Sense, this is bread, and that is Stone; this act is not allowed to brutes who can form no Specifick notions of things, a Dog can conceit bread as a thing more Sutable [and pleasing] to him than a Stone, but cannot conceive it as bread, or a Nature Specifically distinct from that of a Stone.

2. Negative, which apprehends one particular thing not to be another, as that this is not that, this stone is not that bread without considering the Nature of bread or Stone, and this they allow to brutes; So when a Dog hunts out his master, he carryes with him a Phantasm of his Masters Scent; and then when he Smells t[w]o diverse persons he dos (as it were) pronounce that the Scent of this or that man is not like the Scent which he has already lodg'd in his fancy.

2. Reflex acts of Common Sense, are not So much on the objects as the

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[1] With the addition of Aristotle's *De Memoria et Reminiscentia*, the comments on the "interior senses" follow much the same sources as were suggested for the preceding chapter. There is a trace, however, of the Cartesian discussion mentioned in connection with Chapter 22.

Acts of Exterior Senses, So that it judges of the Difference between Seeing, hearing and feeling, etc: as Suppose of a Switch, I See the Motion, [I] Hear the quip, and feel the blow.

N.B. Latter men think all this discourse about common Sense needless, nor do they allow Such a faculty to the Animall, but ascribe all those acts in brutes to the Phantasy, or in man to Cogitation, and therefore they Say common sens is but a notion, and Superfluous; Seeing [all] these acts or appearances in Nature can be Solved by other facultyes.

Common sens objects, Acts, Direct, reflex,
And all the rest do but the mind perplex

2. Phantasy, or fancy is the [second] interior Sens, the Seat [hereof] they place in the middle part of the brain. tis defin'd a Sensative power, whereby the Animall Soul can Apprehend, Compare and Estimate Phantasms, which ar[e] Images ([hence] tis Cal'd Imagination,) or representations of things that have been some way or other perceived by [outward] Senses; Without Sens can be no Imagination, we cannot shape a Phantasm of a angel, though we have a rationall Idea of their nature. Their Spectrall appearances in bodyes of [Conglobulated], and Condensed Air, may be Imagin'd; because bodyes and made Sensible Whether any have appeared with wings (as Vulgarly represented) and of a Golden Colour is to be farther considered; But what has appeared and been perceived by the Senses, has made an Impression upon the Animall Spirits in the brain which Signature is retain'd for Contemplation long after the Sensation is Ended; thus I have an Image of my friend whom I look upon with my thoughts, and with him (as it were) converse dayly, though he be personall[y] far distant or perhaps dead.

fancy is Image-maker in the brain
of absent friends we present Shape retain

2. The Acts of Phantasy are 3 Apprehension Composition, and Estimation.

1. Apprehension of Phantasms, Judging of their truth and goodness [absolute], as whether [they] truly represent the thing [thought of], and whether that representation has any thing of Goodness in it to make it Eligible.

2. Composition when by comparation of Phantasms Sensated the Soul Shapeth Such as pleaseth it, though perhaps never perceived [84] by the Senses; thus we may out of fountains Seen at one place, Groves at another, Rocks at a 3d etc: Shape an [Elizium], a Paradise, or a Place such as

pleaseth us, though there be none such in nature; and thus we can clap wings of birds to bodyes of men or [horses], etc:

3. Estimation of the Goodness, or truth, not Speculative or absolute (as before) but practicall with respect to convenience, or Inconvenience, and So proper to be Chosen or refused by the Appetite.

Fancy dos Apprehend, Compound, Esteam
proper to Appetite, as it dos deem

3. Its Strength, or Vigour gets other Denominations as from the Strength of

1. The two former acts ariseth that which is Cal'd wit, or invension, (or contrivance) as also docility (or aptness to learn)

2. Of the latter act ariseth Vehemence of Passion, as of Love to Dotage, Anger to raving, etc:

4. Its Vitiation is the distemper cal'd madness, which Seams to be but a hig[h]er degree and more fixed State of the last act mentioned; for when the tone of the brain is So altered, and misshapen that it continues in that deformyty, as that the reason cannot act for the fancyes Extravigance, then tis madness; for as a Maimed body is unfit for motion, So a distempered, and distorted brain is for ratiocination. The Difference therefore between madness, and Ext[r]avigant passion Seams to be this; that madness is a broken limb, or a Crooked body which renders it utterly unapt for some motions, whereas the Wild Vehemence of passions (before noted) is but as a [Sprayn], or a Short temporary [and] Voluntary, bowing of the body out of its naturall posture this indeed hinders a Convenient motion for the present but takes it not [quite] away.

from fancyes Strength, and Industry is had
and vehement passion too much makes one mad.

3. Memory the 3d Interior Sens, a Power receiving, retaining and returning Phantasms. Of this the Seat, Object, Acts, Kinds, and Arts.

1. The Seat Commonly Said to be the hinder part of the head; for there in the [Cerebellum] (or little brain behind) we may perceive a working of Spirits, when we would recall Somthing to our [mind], which we have almost forgotten, the hand also by Instinct is directed to rubb or Scratch behind when we cannot readyly recall a thing. The finger (as it were) feelling for the notion, or rather thereby Stirring up the Spirits that are there or drawing more thither to do the Office we require.

2. The Object, Phantasms which if they be materiall Images, they had need be much Contracted, because of the multitude lay'd up in that little

Storehouse they may be Somwhat apprehended by those little pictures of outward objects that are deliniated in the Retina of the Eye, where a Whole Hemisphere may be, and is usually contracted to the breadth of a Pea, and yet all the varyety of Colours, and figures is Exactly represented therein now the memoriall Species may be a contraction of these again, and So contain in them only as it were the Seed of Conceptions, which brought forth to the fancy may Soon in [that] fertile Soyle, grow up, and Expatiate themselves to a convenient magnitude for contemplation.

Memorys place is hinder part of th[e] head,
Its Objects, Phantasms are diminished.

3. Its Acts are the before noted reception, [retention], returning.

1. Reception, when the fancy commits to it the [Image] it hath formed, and of those on which it hath wrought it gives the memory Speciall Charge. Hence the most common cause of defect in youthfull memoryes is [I]nadvertency; in Age it may be plenitude of Images.

2. Retention, this depends partly on the Strength of the Impression and partly on the temper of the brain, and its Spirits which if more dry and Solid, it retains well, though receives ill.

3. Returning, or reproposition to the fancy as oft as it cals for the Species to begin a new contemplation of them.

Memoryes act[s] are taking into trust,
Retaining Safe, and rendering them as just.

4. The kinds of memory are 2. Simple, and Complex.

1. Simple memory is that which is now Spoken [of] common to man, and beast, yea Idiots have it Sometimes, and that in an admirable manner. The reason may be not only a peculiar temperament in Some part of the brain but that all or most of the brains Spirits are only imployed about this work, and few cal'd of[f] or Spent in the Servise of the Understanding. **[85]**

2. Complex or Intellectuall, Joyn'd with Serviseable to, and Established by the understanding. This is Peculiar to men, and is Eminent in wise men, Especially as to things rather than words. The tr[e]asures of this are not only Phantasms, but also Intellectuall Ideas; and it can recal its objects by a Small hint or Circumstance. This by way of distinction from the former common memory is termed Reminiscence, or Recordation.

[Bare] memory in fools, and brutes, is found
Mans Reminiscence hath in reason Ground

5. The arts concerning memory are some meerly fancyfull, Such as making a Romance in the mind, thereby to connect independent words and things. As also that device of making a Strong fancy or Imagination of a room and its furniture, and then referring to the parts thereof the things that one would remember; Such a Course (It Seams) was that Preachers, who mistook his fancyes for his notions, Saying (and now beloved, having [done with] the great windows, we come next to the bell-ropes) but these are toyes. The true rationall helps of memory are more considerable. Such are Serious advertency, frequent Repetition; Especially when one is going to Sleep. Distinct consideration, Ingenious Succinctness, Poetry in referring things to memoriall verses, But above all rationall method. Hence Logick is Cal'd by some the art of memory, for that its distinctions, Topicks Schemes, and methodycall dispositions do lay all things So as we may know where to find them.

True arts of memory Industrious care,
Succinctness, wit, Poetry, memory are.

Chapter 27

Of Sensative appetit

HAVING done with the Sensative Animall powers we come to the appetite whereby the animall is inclined to a Sensated naturall good and is averss from the contrary Evill of this the Object, Seat, Acts, and Passions

1. Its Object are the naturall Good or Evill, foreknown by Sence, whereby its distinguish't from that which is cal'd naturall appetite or mear instinct of inanimates Such as the inclination of a Stone downwards, of fire upwards, etc: but these are not Sensated at all.

2. Its Seat is in the heart wherein are the most manifest mutations in the Vehement motions of Appetite, [Either] dilating by the apprehension of good, or Contracting upon the Apprehension of Evill.

3. Its Acts{Positive Appetision
Negative Aversation}[Either] in a More Eminent degree, are Cal'd passion[s].

Sensative appetite [Its] object, Seat
Its acts, and Passions render it compleat

4. Its Passions which are distributed into 2 Classes Concupiscible and Irascible.

1. Concupiscible appetite is conversant about an Object good or Evill where is no difficulty

2. Irascible the Same Appetite, and Objects where there is difficulty; thus the Antients, Especially the Popish Schoolmen.[1] But others indeed (with better reason) call concupiscible that which is conversant about good, and Irascible on the Contrary, that which is conversant about Evill. And so the Passions may be ranked as the Appetite is carryed with them.

Concupiscible Passions whereby the Appetite is caryed to Good.	Absolute	Love.
	Absent	Desire.
	Absent, and Difficult yet attainable	Hope.
	Absent difficult conceived not attainable	Despair.
	Present	Gladness.

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[1] As Morton indicates, the "Popish Schoolmen" were his chief predecessors in discussing the object, seat, acts, and passions of the sensitive appetite. Here are echoes, for instance, of Thomas Aquinas's "Treatise on Man," Q. lxxvi–lxxxi, and his "Treatise on Human Acts," Pt. II. See *The "Summa Theologica" of St. Thomas Aquinas*, translated by Fathers

Irascible in Aversation from Evill.	Absolute	Hatred.
	Absent	Flight.
	Absent difficult and Superable	Boldness.
	Absent difficult conceived insuperable	Fear.
	Present	Sadness.
	[Inferred] by Spontaneous Agent	Anger.

N.B. Affections, and passions are common names to all yet Vulgar Use appropriates affections to Love, and the other concupiscibles, and passions to the Irassibles Especially in Anger and Griefe but though we Speak with the Vulgar we must think with the Wise. The like also may be Said of the Equivocall name of passions ascribed to those which are indeed actions of the will, or appetite, and those vehement in their kind. [86]

N.B. All have Yoak fellowes Except anger because its Correspondent which should [be] Gratitude belongs not to Animalls in Generall but to man in Special [as] other humane passions of which See more in Ethicks.

Good	*Modes*	*Evill*
Love	Absolute	Hatred
Desire	Absent	Flight
Hope	Absent, with difficulty	Boldness
Despaire	Absent Difficult [Insuperable]	Fear
Gladness	Present	Sadness
Gratitude	Spontaneous Agent	Anger

Passions Concupiscible are of Good
Of Evill Irascible Understood
And not as Som would have it Irascible
Where Difficult, Where not Concupiscible.

of the English Dominican Province (22 vols., London, 1911–1925). Descartes covered the same material, under a classification somewhat varying from Morton's, in *Les Passions de l'Âme.*

Chapter 28

Of Locomotion

THE 3d Primary affection or Power of Animal in Generall (after Sens and appetite) is Locomotion.[1] whereby the Animall is able to remove its Self in whole or part from place to place, for the Acquiring Some good or avoiding Som evill, of this consider the Principle the Manner, and the Species or division.

1. The Principle within the Animall is the form intimating to the materiall Spirits in the nerves, that are ingredients into the Muscles of the bodyes whose tendons at Each end are fixed to the bones.

2. The modes or manner of motion is by thrusting in or commanding forth a Sufficient Quantity of Spirits 1st from the brain and then from the Great nerve going through the back bone, Cal'd the pith of the back which are the fountain and [Source] of animall Spirits into these rivelets and derivations of the Severall payres of nerves that proceed from it and are distributed into Each muscle of every limb.' Some one particular muscle being thus Inflated (or puffed up) with Spirits, it grows thiker in the middle, and therefore the distance of its Ends must be Shortened. Now one End or tendon of the Muscle being fastened to a fixed bone, and the other to a Moveable one, The Moveable must by consequence [come home], and So the motion of a part is performed. This moved part being thereby applyed to another part of the Earth than that whereon it was before and the Center of the bodyes Gravity being also removed forward by other muscles, hence arises progression or a motion of the Whole.

All the Difficulty lyes in these words (form Intimating) for this form if it be matter how comes it to move its Self, or Give intimation. Objective motion is but by perception, and not Efficatious attingence, and how can matter perceive. Or if on the other hand it be Spirit, that (being Immaterial) canot protrude matter, or push it on, but will rather penitrate it; Somwhat like as we See light goe through a diaphinous body, without removing it. Besides hitherto most Phylosophers have been very Shy of allowing Spirits to brutes lest thereby they Should render them immortal, or Incorruptible because of their indivisibility. Cartes tells us [that objective] motion is no more than pulling the tricker of these machines, or applying the Linstock to a Canon, and So a Small motion may put a greater on work. Thus when I Whistle my Dog, all his Spirits are put in motion, by the Small touch of the Timpanum or Drum of the Ear, from the Air Vibrated by the Whistle. And So by the motion of the finger, a taught Eliphant has his whole [vast] body put into motion, the tricker being in his Eye beholding the fingers little motion. All this they Say is possible because of the Immense knowledge of the Oppificer of the machynes, and therefore mens Impotens to make an Engine like this hinders not its probability. But Still the Difficulty Seams to remain in the perception, and the Direction of motion. The docility of the Eliphant is not only from the memory which they give to it from a Certain perforation of the brain this or that way but from a perception 1st of the difference between the bit and the Knock. (the Reward, and Punishment) which if mear matter doth perceive, *Learn* be conscious. Remember, etc: I must needs Say as Cartes himself dos in another place, I will not Say, It is impossible to God, but that he has [not] given me Such a Soull as can understand it.

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[1] Two of Aristotle's biological treatises, *De Incessu Animalium* and *De Motu Animalium* will be found to have some bearing on this section. Morton's physiology of the nervous system is derived, however, from Descartes' *De Homine*, perhaps through some such intermediary as Legrand, *Institutio Philosophiae*, Pt. VIII, ch. vi. See Charles Singer, *A Short History of Medicine*, pp. 127–129. The mechanistic implications, here quite evident, were more fully developed by Giovanni Alfonso Borelli, whose *De Motu Animalium* (Rome, 1680–1681) may possibly have been known by Morton. The discussion of the souls of brutes continues the question raised before in Chapters 22 and 26.

Form is the principle of Locomotions
But of the Mode Men vary in their notions.

The P[h]ainomina in Brutes, and appearrances in their nature Especially as Docile cannot be Solved to my understanding, by figure of matter and Site of parts. And [yet] tis not in my reach to Settle a better hypothysis. however it may be proposed to consideration.

1. That the Souls of brutes are truly Spirits, and do act in brutes as reasonable souls do in men; namly, by Intimation and command to the Spirits that they rush into this or that muscle or member as the Animall pleases. [87]

2. The Spirits that are the formes of brutes are either [mortall] or vanishing as accidents Seperated from the matter or Substance. This Aristotle calls a returning into the Power of [the] matter, Like the figure of Wax. And the Scripture Sayes of the Spirit of a [beast] that it goes downwards to the Earth; (Ecclesiastes. 3.2.) where we may note that they are cal'd Spirits both of man, and beast, that they are determin'd Severall wayes by the Creator, Mans Spirit upwards to God the Judge, Beasts Spirit downwards to the Earth; and then that in those abstruse matters

there is a transcendency to the Knowledge of men intimated in the words (who Knoweth) or Else these Spirits of brutes are permanent as mens are; but of this we Know no Use or reason. Supposing therefore these brutall Spirits are true Spirits, and yet perrishing, we may conceive the Gradation of Created Spirits in this order.

1. Some Spirits Created are without any relation to matter at all as Angell.

2. Other Spirits are created with relation to matter but without dependence, not necessarily or alwayes to be conjoyn'd therewith. as the Souls of men whom the Creator (for holy ends) will make to Subsist in a State of Seperation.

3. Others with relation, and dependence on matter necessarily therein with conjunction thereunto, by the Creators will while they have a being, as the Souls of brutes which may vanish at their Seperation for that they have attain'd their End. And there is no further Use of them.

4. Matter Volatilized, and put in motion, is Somtimes Equivocally cal'd Spirits as the form or Life of Vegitables, and those Steams cal'd natural, Vital, and Animal Spirits in the bodyes of men and beasts

5. Matter fixed, and quiescent, at least in the Greatest, and Cheif parts thereof as in all [Inanimates] that have nothing Cal'd Spirits.

Angels no Use of matter man no need,
Brutes must; All else meer matter is indeed

And thus the Order of things, and harmony of the World appear, without that great Gapp [between] Spirituall, and bodyly Substance. As to those who would have brutall Spirits or Souls to persist in being after their Seperation; for this they fancy a certain generall Spirit or Souls of the world from whence they came first, and to which they return; Like as all waters are from and goe again to the Sea. or Else they conceive [that] the Spirit of a brute when it dyes passes into the Air, and therein houvers untill it be affixed to Some plant, or other nourishment proper to that kind of Animal whence it came, and So may it pass into the body of a Generant, joyn it Self with the prolifique Seed, and So become the form of a New Generated animall of the Kind.

This indeed may be; but I do not think it is, for God can as well create a new Spirit as preserve the Old in this wandring condition; and then there is not the Same reason for preserving these as there is for the Spirits of men who being made Subjects of Morallity are fit objects of Divine Justice, and mercy to be manifested [upon them]. That which has inclined [Some to think that] these Spirits of brutes are not continually created (as the Spirits of men are Generally acknowledged to be) in Every individuall was a care lest this should Depretiate too much the Divine creating power to bring it down to Such minute things; Not Considering (meanwhile) that the Same reason would overthrow Universall Divine Providence, which Extendeth itself also to the most minute matters without Derogation; yea to the magnifying of his infinity who upholdeth all things by the word of his power. Do but Conceive of God as the fountain of all beings, and that all out of him are but Emanations from him, and you may then without difficulty think that any Ray of being which proceeds from him may be withheld at his pleasure, and so there will be no need of a positive Exerting of his power to Annihilate any Creature he hath no further Use for; Seeing a Negative withholding his Influence will Effectually do it. And the Same you may [conceive] of his bestowing beeing where and when he pleaseth.

From hence it follows that the Immortality of humane Souls, yea of Angels themselves is not So much from their Spirituall nature which is indiscerpible, Indivissible, or Incorruptible; for so in all respects is Every atome of matter; but it is from the Will, and Influence of the Creator who will have it So to be. Hence also it follows that the Argument to prove the Souls of brutes not to be Spirits because Perishable, or that the oppinion of a perrishableness in any Spirit will distroy the Immortality of humane Souls, will not hold; for tis enough to say God has not declared the permanence of brutall Spirits nor the reason for their permanence, as he hath of Humane Spirits namly the Gloryfying of Justice, and Mercy to all Eternity and therefore no wonder if he lets them fall into their first nothing when they have Served men their appointed End, and done the work for which they were created. And thus much of the principle, and manner of Locomotion. [88]

Spirits of Brutes do perrish: permanence,
have mens, from divine Ends, and Influence

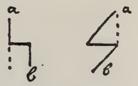
3. The Division of Locomotion is into totall, and partiall.

1. Totall, when the whole body is removed [for] acquiring some good or removing some Evill. These are Jumping, Going, Creeping, flying, or Swiming.

1. Jumping as Grasshoppers, fleas, tripping of Does etc: Depending on the figure of the hind legs, or Strength of the muscles.

2. Going, when the feet are Interchangeably put forth, and the upper part of the body poysed forwards the better to lift the hinder Legs and bring them Successively into their place; for as one cannot rise from a

Seat till the Center of Gravity be removed forwards, as in the Diagram if [one] Sit Erect (as in the first figure) So as the line of Gravity be the pricked line, directly down from the head (a) [and] the heels (b.) being forwards he cannot rise, but if the head (a) be Stooped forwards, and the heels (b.) be Set back (as in the Second figure) that the line of Gravity Come forth to the middle of the Seat, then the forepart will Counterpoyse the hinder part and one Easyly ariseth, So tis in going for a man cant go till his head be over his forefoots heel, and that will Ease his hinder foot to rise, and draw it forwards to take the next Step, Hence falling upon a Stumble is when the Sway of the Center of Gravity forward is too violent to be commanded, and hence wearines is the Sooner, and Greater by an ill, and unsteady poyse of the body Especially of the head.



N.B. The Gymnick arts, Such as Dancing, fencing, Vaulting, wrestling etc: were invented and taught for the regulating of this poyse, and therefore are of Great Use however abus'd by mens Corruptions.

3. Creeping (by Creatures that have no legs) is a Shoving forwards of the Body by the Shells of the Animal hitching in the Earth. So an Earthworm Snail, or Serpent being at length, draw in their tailes, and Clap them against the Ground and there they Stick because the points and Edges of [their] Scales or rings do point backwards; then they thrust their heads forwards which they may Easyly do because their Scales do not that way hinder them then the fore part is fastened to the Ground and the tailes are drawn up again, etc: hence it follows that upon a Smoth, and polished thing Such a Creature cannot move onwards, or have any progressive motion.

4. Flying, or Swiming, (for they are both of the Same nature one with the other, and with rowing in a boat) is when the Wing beats, or thrusts against the Air, or the finn against the water to cause the Animall to move the Contrary way to that thrust or beat, the figure, and opening of the Wing is Contrived with admirable wisdom for this purpose; as we may See by the naked Eye; but the texture of Every feather, gives, in the Microscope a Sight most astonishing. Artificiall wings might be made proportionable to the body of a man, but then the Strength of the Arme could not be Sufficient to move them, however tis Conjectured by Some that as oars have been Substituted for finns to [enable] men to pass on water, So after ages may find out a Substitute for Wings so applyed to an Engine, that may row us in the Air, as a boat doth in water.[1]

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[1] Morton, perhaps influenced by his teacher, John Wilkins, had more than ordinary interest in the conquest of the air. See Morton's "Enquiry into the Physical and Literal

Whole Locomotion with the needs complying
Are Jumping, Going, Creeping, Swimming, flying

2. Partiall motion is of particular members, according to their Use and figure, and this Especially as the Ends of the bones are Shaped, and Joyned to other bones, these are Absolutely Arbitrary. but there are two particular motions of another nature, namly the motion of Air in our Lungs, and [of spirits and] blood in our heart, and Arteryes, these are Generally out of our Cognizance, and are not at our [disposall], I doubt not but the mind causes them but with Such a necessity of nature that it does them without reflecting upon them, in the Intellect or Exercising will about them: tis in this as with a man in a Journey when once he hath begun, and determined his End, and way, the mind makes many thousand Steps with the feet which it never thinks upon nor can do any other wise than make them while the End of the way is designed. These are Cal'd respiration, and Puls.

1. Respiration is a motion of the Lungs, by Dilatation attracting air for the Cooling of the Heart, and attempering of the Spirits, and by Contraction casting it out again with the Heterogeneous fumes, when it hath done its work, The Cheif use Seams not the cooling (only Antiently ascribed to it) but to Supply matter for Spirits and by Ventilation to Sustain the motion of the flame of life which would Soon be extinguished without it.

2. Puls, a particular motion of the heart, and arteries whereby in dilating and Contracting, (Cal'd Systole, or Diastole) the bloods Circulation is continued the Arteryes Still carrying out blood heated, and Impregnated with vivid Spirits, and the veines return-[89]ing it when depauperated to be again recruited (as is before noted) The Difference of Puls indicating the State of the blood and Spirits is variously distinguished by Physitians, into high, Low, hard, Soft, Even, uneven, Swift, Slow, etc: The time of an ordinary puls is [one second], that is [$\frac{1}{60}$] part of a minute, and then there will be 3600 in an hour, but Anatomists reckon 2000 the least, [and] Some near 5000, as [Spigelius][1] 4876. The Quantity of blood passing

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Sense of that Scripture Jeremiah VIII, 7," in the *Harleian Miscellany* (2nd ed., London, 1744), II. 558–567; and cf. Marjorie Nicolson, "A World in the Moon," *Smith College Studies in Modern Languages*, XVII. No. 2. Morton was proposing the hypothesis that swallows and storks and their kind wintered in the moon.

[1] In the Ward MS., used by Mr. Morison, this statement is attributed to "Hevel." In the other American transcriptions it is clearly "Slegelius," and may perhaps refer to Paulus Marquart Slegel, author of *Disputatio de Haemorrhagia* (Jena, 1640), listed in the British Museum catalogue. In the Bodleian MS., however, "Spigelius" is inserted as a correction. The reference is probably to *De Humani Corporis Fabrica* (Venice, 1627) by Adrian van den Spieghel (1578–1625), a Flemish anatomist.

the heart at every puls, is also variously accounted; Some reckon by Scruples and Drams, others by Ounces. Harvey Sayes, the left ventricle of the heart will hold 2 oz., and if all or most of this be cast out at every puls, (as the latter learned men think) and there be in men [blood] from 15, to 25 lb. then by Computation 'twill appear (taking the puls at 2000 in an hour) that all the mass of blood pass[es] through the heart [about] 13 times in an hour.[1]

All partial motions are Arbitrary
but Puls and Respiration necessary

And thus much of primary animall powers, Sens Appetite, and motion. Next follow the Secondary Awake, and Sleep.

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[1] In his remarks on the pulse Morton deals with what has been called "the crucial point in Harvey's argument," and "a most important question ever since." See William Harvey, *Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus* (Tercentennial Edition, with an English translation and annotations by Chauncy D. Leake, Springfield, Ill., and Baltimore, Md., 1928), pp. 75–76 *n*. Apparently Morton does not draw directly either from Harvey or from Harvey's most important follower, Richard Lower (*Tractatus de Corde*, London, 1669). See Harvey's treatise in Leake's edition, pp. 73–76, and Lower's treatise, prefaced by an introduction and translation by K. J. Franklin, in R. T. Gunther, *Early Science in Oxford*, IX. sigs. G¹–G². Harvey supposes, for the sake of his argument, that the left ventricle holds one half ounce (four drams), three drams, or, as he says, even one dram. Lower says, perhaps through information from other sources, that Harvey estimated two ounces. On this vital point in the computation Harvey is indefinite, since it does not matter to his argument. Legrand, *Institutio Philosophiae*, Pt. VIII, ch. vii, estimates that there are 64 pulses per minute, 3,840 per hour; that there is one dram of blood in the left ventricle; and that the weight of the whole mass of blood is "scarcely above 10 Pounds." Hence he arrives at the estimate that all the blood circulates through the heart three times each hour. Lower estimates six times, Morton thirteen.

Chapter 29

Of Secondary Affections. Awake, and Sleep

SECONDARY Affections are in the Animal by means of the former, which do first, and Immediately affect them the Most notable are Awaking, Sleeping.[1]

1. Waking is a State of the Animall, or mode of Existing wherein it can freely exercise the opperations of the Senses; this is one of the (Per se nota) things known by themselves, and Indemonstrable, because of them we can have no greater Evidence.

2. Sleep a State or mode of [Existing] wherein the Exterior Senses, and that which is cal'd Common sens are obstructed in their operations, for the health of the Animall, and restauration of Spirits. Tis caus'd by the Steams of food and blood ascending into the brain, by whose coldness they are Said to be condensed into moysture which obstructs the passages of the Spirits that they cannot freely permeate to the Organs of Sens. But it Seams rather that nature intending but one work at once causes those vapours to lye, and ferment with the Spirits allready formed, and by their mixture the finner parts are volatilized into the Same nature with the Spirits. So that as blood makes blood by Circulating the Chile with it. So Spirits make Spirits by their fermenting togather with this Vaporous matter: and while this work is in doing they have not leisure to attend the Senses. And thus the continual Evaporation of Spirits is recruted, and the Animall is revived, and refreshed.

Waking's a state of th' Exercise of Sens.
Sleep dos recrute the Spirits great expence

An Adjunct of Sleep is dream, which is the active fancyes entertaining itself (while it hath nothing else to do) with the Phantasms layd up in the memory, or newly formed out of the ascending steams. Which because it dos propose to itself no orderly design in working, are therefore very confused, and independent, much like the Impertinent thoughts of an idle and unemploied person; the Discourses of Impertinent visitants, the running of Children, the frisking of Lambs and Kids when they have no design, but by Instinct are inclin'd only to Exercise themselves, no matter wherein, or after what manner.

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[1] Many of the notions here go back to some of the brief treatises in Aristotle's *Parva Naturalia*: namely, *De Somno et Vigilia*, *De Somnis*, and *De Divinatione per Somnum*. Legrand, *Institutio Philosophiae*, Pt. VIII, ch. XX, reveals close verbal correspondences; for example: "Waking is the free Exercise of the Senses, depending on the uninterrupted influence of Spirits into the Organs."

Dreams are the frisks of fancy without End,
Only a little Idle time to Spend.

In men dreams are not only the operations of fancy, but Somtimes also [of] the Intellect, and then there is more order, and connection in the Ideas. These are either natural, or Supernatural.

1. Naturall, when Excited by naturall Causes Such are Strong impressions made by late business or Intelligence [of] more than ordinary concern, or the humours of the body notably alter'd, and dispos'd, either to health or Sickness.

2. Supernaturall, and those are either divine or Diabolicall.

1. Divine dreams from God. or Good Angels, Exciting species, and presenting them to the fancy or Intellect; this [was] one of the wayes of revelation and prophesy.

2. Diabolicall when the like is done by Evill Spirits insinuating themselves among those humours, and Steams, and forming out of them Such Phantasms as disturb, and truble, and so hinder Sound Sleep, and Impaire the health, or else Such as may tempt to (at least the Shaddows of) vice, which have a kind of tendency to confirm habits of Sin, and therefore Should be matter of repentence, not as formall acts of Sin, but as tokens and Cherrishers of imbred corruption.

Mens dreams have reasons mixtures; [Gods] infusions
Or Satans tempting, troubling curst delusions.

And thus much of the Sensative natural body in Generall now of the Species thereof brute, and man.

Chapter [30]

Of The Species of Animall, Brutes, and Men

1. BRUTE is the Unreasonable liver,[1] as oppos'd to the rationall, these have all the forementioned facultyes, but falling short of reason; this is the Commonly received notion, though they say also that Some of them which are Cicurable, (that is most apt to be taught, and tam'd by man) as Dogs, Elephants, horses, etc: have their [Shadow] of reason, I may Add, and of naturall conscience too. for they Seam to have a sence of fault, and guilt if they have offended, and Some [Kind] of [Self] Satisfaction, and pleasure, when they have obeyed their Immediate Lord (man) and done as they have been bid: But no Sentiment of a deity or worship could ever [90] be observed in them, and therefore Some lerned men are inclined to think religion, and not reason is the Essentiall difference of man from a brute.

Shaddows of reason in a brute we Spie
but no religious Sens of Deity.

Brutes are either perfect, or imperfect.

1. Imperfect Such as are without blood or breath cal'd insects, because of the Scissures, and divisions in their bodyes, Such are all the kinds of flyes, Ants, or other Creepers covered with Shells; also fleas, Lyce, Leeches, are accounted of this Sort because they have all their blood in their Stomacks, as food Sucked from other animals. Quere,—If a lous kept fasting a day or two, has he that little parcel of blood which we Se moving in him by the help of a Microscope. Such creatures as want Lungs, and breath have no voyce, therefore the humm of bees, and flyes is all from the vibration of their wings. And the noise of Crickets and Grasshoppers, are Said to be rubbing of 2 Shels of their back one against another by lifting up, and letting fall their tailes.

Without both blood, and breath Imperfect brutes
May buz or Creek, but as to voyce are mutes

As for the Generation of Insects out of Putrid matter; tis taken notice [of] as a mistake before in the Generative faculty.

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[1] This chapter, somewhat remotely related to the *Historia Animalium*, echoes the Cartesian discussion of the animal soul touched upon previously in Chapters 22, 26, and 28.

2. Perfect, is that which hath So much blood, and heat as to need Lungs, or Somthing Analogous to them for refrigeration of the heart. These are Either Amphybous, or heterobious.

1. Amphybious, Living in both Elements air, and water, as froggs, Crocadiles, Land crabs, Sea tortoyses, or if there be any more of that kind which are not only long divers, as Otters, Beavers, etc: but to whom the Water Supplyes the want of Air yea and is Somtimes more convenient for them; so is water to frogs all winter; because its then more warm than the Air.

2. Heterobious, Such as can live in one of the Eliments only, as air or water, (Earth and Fire being unsutable to Animall nature) and tho it be vulgarly Said that Salamanders live in the fire, Moles, and Earth worms in the Earth, yet better observation Shews that Salamanders live but as Creekets, near the fire for warmth, they being of an Extream Cold nature, and moles breath though but that little Air which is strayned through the Earth, which is enough to Serve their turns. Earthworms live more on the moisture of the Earth, and are nearer of Kinn to the Amphybious. These Heterobious are divided according to the places where they mostly reside or delight, as water, Air Earth:

1. Watry, fishes that Swimm, at least live in waters these have their gills instead of Lungs and therefore Even a fish may be drowned in water if [these] gills be tyed up. Fish are of Divers Kinds according to their

$$\text{water,}\left\{\begin{array}{l}\text{fresh}\\ \text{Salt}\end{array}\right\}\left\{\begin{array}{l}\text{Shelly}\\ \text{Scally}\end{array}\right\}\left\{\begin{array}{l}\text{Moving}\\ \text{Quiescent}\end{array}\right\}$$

2. Airy, birds that fly in the Air, Some more Som less.

3. Earthy, beasts that Goe, Leap, or Creep upon the Earth or dry Land. These two latter airy, and [Earthy], are variously divided into

$$\left\{\begin{array}{l}\text{Carnivorous}\\ \text{[frumentary]}\end{array}\right\}\left\{\begin{array}{l}\text{Wild}\\ \text{Tame}\end{array}\right\}\left\{\begin{array}{l}\text{Usefull}\\ \text{hurtfull}\end{array}\right\}\left\{\begin{array}{l}\text{Cicurable}\\ \text{Undocile}\end{array}\right\}\text{etc:}$$

Their highest degree of perfection, is their nearest approach unto man, and that in likeness, delight, and Servise.

$$\text{1. Likeness either in}\left\{\begin{array}{l}\text{body, as Monkeyes,}\\ \text{Soul the most ingenious, and Sagatious as Some}\\ \text{kind of Dogs.}\end{array}\right.$$

2. Delight in mans Company as Doggs, and tis Said Lizards.

3. Most Serviseable, and Delightfull to man, because all made for his Use, and given to him by the Creator.

Some brutes in air or water are Secure,
All others only one of these Endure.

The Cheif perfection which belongs to these
is likeness unto man to love, Serve, please.

And thus much of the first Species of animall, [Brute].

2. Man (the Other Species of Animall) is commonly defin'd the [Reasonable] animall because reason was thought the Essentiall difference. but indeed there [is] So much like reason in some brutes, (as has been Intimated) that it is not altogather without reason that others have placed the difference in religion, for there is no man but hath a Sentament of a Deity, and there is no brute that has the least appearrance thereof. No man, (what ere they pretend) can be really a Speculative Athiest, but practicall atheists there are too many, who Say in their hearts rather than in their heads there is no God; their Corrupt will, and Affections rather than their Judgment inclining them so to think.

Mans difference in religion you may State
rather than reason which brutes immitate

In Man there are considerable their bodyes, and their Souls.

1. Their bodyes which are wonderfully made with that majesty that Scarce the wildest creature undisturbed by hunger or Anger dares look him in the face, or assault him; God haveing So put the fear of man into every Earthly creature. The humane body is distributed by Physitians, and Anatomists into
Containing — Cavites — Scheleton — Bones Muscles, Arteries Veines, Nerves.
Contained — Limbs — [Scheams]

Of all which See their proper treatis in Anatomy.

Mans body's beautifyed with majesty
Its parts discrib'd are in Anatomy.

2. Their Souls which are considered as beings or forms

1. As being So they are Spirits contradistinct [91] in the predicament of Substance [to] bodyes. Souls are individually created of God (the father of Spirits) [and] in the Same moment infused into man; yet as beings are Capable of Existing Seperate from the body. And thus (as Seperate) they have been formerly handled in the Speciall part of metaphysicks: but of late they are referred (with good reason) to a Distinct Science, Cal'd pneumaticks or [the] doctrine of Spirits, as Physicks is of bodyes.

As beings Souls are Spirits which remaine
Seperate untill they are Conjoyn'd againe.

2. As forms So their Conjunction to the body is necessary to their

being such and is of the most proper physicall consideration. They are therefore in the very moment of Creation, and Infusion from God united also with the body, by the plastick, and formative vertue, in the parentall Seeds So that the parent truly Generates the man though he does not produce the form, because the proper Generation consists in the Union, and not in the production of the parts.

This well considered will help us to understand the propagation of original Sin, tis not from body to body, nor from Soul, to Soul, nor from the body to the Soul but from the man to the man. Nor does it derogate from the Excellency of mans Generation that his Childs Soul is not educed [or] Excited, as they say Dogs and other brutes Souls are by the Generant, because the bare Union of the humane Soul being So [far] more Excellent than others, renders it a more Excellent and noble Generation than that of traduction, (if it be so) of brutal forms.

As forms, Souls must united be; and this
begetting nobler than [traduction] is

The Powers, and facultyes of the Soul wherein it differs from that of brutes belong to it as Spirit, and therefore the doctrine of it belongs properly to pneumaticks. but because their operations, whereby these facultyes declare themselves in the State of Conjunction do Somwhat depend on the body; Especially the temperament of the brain, and heart, and because otherwise man cannot be well Specificated from brute, the other Species of animall, therefore Physicks take notice of them, and they are primary or Secondary.

1. Primary are the Intellect, and the will which [do] immediatly result from the nature of the Soul, and are therefore Cal'd inorganicall facultyes, as not affixed to any member of the body, So as Sensative, appetive, and Locomotive powers are to their proper organs, and yet indeed they Seam to have most to do where those facultyes reside which do more Immediately Serve them; and therefore in those parts they may be Said to have their Cheif Seat, and throne. thus the Intellect having most to do with fancy and memory is Said to reside in the head; and (say the Cartesians) especially in the Glandula Pinealis, a little Kernell in the Center of the brain, formed like the Seed of a pine, though others will not allow that trifle lying among the fœces of the brain that transcendent honour. So the will managing [mostly] the appetites, and Affections, is Said to possess the heart, hence the Phraise (I will with all my heart) and hence also a Good head, and heart are put in a Vulgar metanimy for a good understanding and will.

The Intellect and will [in] head, and heart,
Command, though not oblidg'd to any part.

Of these in particular.

1. The Intellect is a power of the reasonable, (or religious) Soul, whereby it understands truth; Its Improvement is by Logick (the art of reasoning) and all the Speculative Sciences, [in this] Consider

1. The Acts of the Intellect are either incompleate, or Compleate.

1. Incompleate or preparitory, are forming or receiving Species.

1. Forming Species Intelligible, or Ideas of things is out of the Phantasms in Clearing them by abstraction from the conditions of matter, and So making that Actually intelligible, that was but potentially So before, as thus. I know a Man that is my friend and has done me freindly offices in a time of adversity; when I think of him I first have a Phantasm of the mans person, and his Action, with [its] Circumstances of time, place, etc: before my thoughts; Hitherto is the work of fancy, but now my mind from this formes [the] Idea (or intellectual Species) of a true friend, and ascribes to him (that he loves at all times) this Idea of a friend, the Subject of [that] proposition (a true friend loveth at all times) is now by Intellect abstracted from the Colour, Stature, feature, and other material conditions of [that] person, and is the proper Intelligible Species of my reall friend.

2. receiving of this Idea So formed, and Abstracted to be the object of my Cogitations, and concerning which I am about to Set my thoughts to work as [92] suppose (in the former Instance) how I ought to Esteam Immitate, reward, and Carry myself towards Such a friend.

Int[e]llect forming Species; matter leaving
fits them for Int[e]llectuall receiving.

2. Compleat which is the formall acting of the Intellect upon this object, whereby that which was before (While a Species) but actually intelligible, is now actually Intellected, or Understood; as Suppose I do now actually think Such a true friend as is before mentioned is to be loved, thanked, Served, trusted, etc: The compleat act is 3 fold.

Apprehension of Simple terms
Composition of them in [propositions] { Affirming / Denying } Of all which in Logick.[1]
Discourse { Illative in argumentation / [Ordinative] in method }

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[1] Morton's "reactionary" logic is discussed at some length in Perry Miller, *The New England Mind* (pp. 121–123). A glance at Mr. Miller's index will reveal, moreover, his considerable use of the *Compendium Physicae* in the synthesis of seventeenth-century New England thought which he has made.

N.B. These [a]forementioned distinct acts are not ordinarily observed by us in our discourses, no more than all the motions of my Eye, hand, or Pen in writing these lines, are considered by me; and yet tis manyfest when I do think [of it] there were So many distinct motions of them all in [the] writing Every letter.

Intellects formall acts are t'apprehend,
Compound, discourse, to direct Logicks End.

And thus much of the Acts of Intellect, the next is its Object.

2. The Object of the Intellect is truth, Simple, and Complex.

1. Simple is when the Idea Answers to the thing as it is.

2. Complex is when the Affirmation or Negation do So answer; hence falshood in the former begets falshood in the latter, for if I apprehend Alchymy to be Gold, I readyly (though falsly) affirm (this is Gold)

Intellects objects, [truth] when tis display'd
Simple, or Complex as tis thought or said

This of the Object, next follows

3. The distinctions of Intellect into Agent, and patient, and into Speculative, and practical.

1. into
Agent as forming Ideas
patient, as receiving them
both these are but the Same Intellect under a diverse formality of Acting.

Suppose a tutor in teaching represents a notion to his Pupill; the Intellect of the pupill is first patient, but tis afterwards again agent when he thinks Seriously thereupon. This Instance of another mans Idea formed to our hand is proposed, as more Easy to conceive, but the reason is the same when all the Acts are in the Same Intellect; for in them the Intellect is first agent in forming, then patient in receiving, and then agent again in Cogitating thereon.

2. Into
Speculative which is Satisfyed in the naked Contemplation of the thing,
Practical which So Contemplates objects that they may be also practised.

As When a Man Studdyes archytecture, and Contemplates the reason of [the] proportion of parts (as Suppose that it depends upon Musicall harmony, and the Numerall opperations of Arethmetick) this he may do without the Idea of any house in his thoughts, or without any design of building. But if as an Archytect, he would contrive a house, now his practicall Judgment works and forms [an] Idea of what he intends, and Contemplates thereon to Examin whether it be agreable to the Aforesaid Speculations. yea that his Idea do not fleet out of his thoughts he Commands fancy to [shape] a well materiated Phantasm thereof, and to help Imagination he draws visible lines or rather frames a visible, and tangible model; this he Changes according to his aforeconceived Ideas untill he has [formed] one that is in all points to his Satisfaction.

Agent and patient Intellect's the Same
Speculative thinks but practical dos frame

This of the Distinction of Intellects

4. The Subservient to the Intellect is the Intellectual memory which is carefull of receiving, Laying up, and returning intellectual Species, and Ideas (as the brutall memory can store up Phantasms) this is Greatly helped by Good method. hence Logick [in this respect] is Cal'd [by some] the Art of memory. The Exercise of intellectual memory dos mostly belong to wise men and Scholars. Whereas fools and Children have the more common Use of the other; for that they are unable to form those abstracted Ideas and are less Capable of rationall method.

Memory Intellectual Serves the mind.
Children, and fools use that of th'other kind

N.B. he that would Gladly hear Sermons, and remember them, had need to understand the Usuall method in which they are made and therefore its most profitable for hearrers that preachers mostly keep to the Usuall method of Explication, Doctrine, Proof, reasons, and Use. for thereby the ordinary hearer has his topicks, or Common places whereto he may refer what he hears and Easyly recall it in Order by meditation.

He that would Sermons profitably hear,
had need to Understand the method Clear.

N.B. that all Speculative learning helps to form mens minds to Contemplation, and therefore mathematecall demonstrations, Arithmeticall opperations Algebra, etc: are very profitable to those who may never have [any] proper Use for them because they beget an Accumen, or Sharpness of wit, and Judgment besides an habit of not being Satisfyed without clear and manifest reason. And then be Sure those Abilityes are Applicable to any other business whatsoever.

To be Contemplative is not Easy unless men Inure themselves thereunto. hence [Easy] Students that love not too much to beat their braines in contemplation; desire to [**93**] have things represented to the Eye in Diagrams, Picture[s], etc: because they are more inured to Phantasms, than Speculative Ideas. And hence the Grossness of popery, and all sorts of Idolatry appears in that the Objects of their devotion must be Gross materiall, and Sensible, and the Acts of it consist much in bodyly Exercise and outward rites, meanwhile the Spiritual worship which God requires is accounted too fine for them because they will not truble themselves in any abstracting Labour. And this Shews the true reason why Corruption inclines them naturally to Superstition, and Idolatry. Which Else would appear too Gross, fulsom, and absurd for any reasonable Creature. And yet it must be confest the most contemplative men while their Souls are in a [State of] Conjunction with matter and Especially under their naturall infirmityes contracted by the fall will need materiall helps to fix their contemplation; hence many say they can mind better when they hear themselves to read, and can pray with most intension when they speak aloud, at least Audibly; If this indeed to any person be almost necessary in nature tis an Infirmity to be pittyed. But if contracted by the Errour of Education in the Scurvy Custom of bawling at Grammer Schools while they learn their lessons it must be Striven against, and Endeavoured to be reformed: What may be Us'd for an help must not be abus'd in an Idleness or Oscitancy of mind; but by Such helps men should Endeavour to be able not to need them, and to attain what they may an ability of Abstracted contemplation.

Abstracted Science helps wise Contemplation
Idleness is pleas'd with dull Imagination.

And So much for the first primary power of the reasonable soul; Intellect.

2. Will is a power of the reasonable Soul whereby after the information of the Intellect it Closeth with Good, and Shuns Evill of this consider [the] Objects, and Acts.

1. The Objects of will are Good and Evill, So appearing at least under present Circumstances whether they be really So or no.

2. [The] Acts are Either Elicite or Imperate.

1. Elicite acts of the will are such as are drawn forth, and Exercised in, and of its self, without any help of Inferior facultyes; and these are either positive volition of Good, or negative nolition of Evill.

2. Imperate, or rather Imperant whereby it commands the Inferior facultyes, whence acts may be rather cal'd imperate.

Wills objects are appearing Good, or Ill.
Acts are Elicite, imperate, will, nill.

besides what [is] mentioned there are appartaining to the will its imperfect motions called Veleity, and Noleity. Expressing themselves by would, as I would or would not, instead of I will or will not. And Its mixed inclinations which will for one reason, and will not for another. Also its Obsequiousness to the Last dictates of the Understanding, Its Liberty in rationall Spontaneity, Its Concern in Vertue and vice, and its different volition of End[s], and means, etc: of all which having Spoken Largly in Ethicks, we shall now pass them here. These 2 Understanding, and will are commonly accounted the only primary facultyes; but there seams to be a third Cal'd Conscience I know this is accounted an act of the practicall Judgment, concerning a mans Self and his actions; Defined, the Judgment of a Man Subjected to the Judgment of God. In Which the Word (Subjected) carryes a yeilding and Subjective act of the will. So that I should rather think tis either a Complex of both; and may be defined an Aptitude for, and Inclination to religion; or an higher facultye comprehending both the other; as we See reason doth all the powers of a brute, and then it may be defin'd the Differentiall power in man, whereby he can Acknowledge God. having intellect, will, and all other facultyes Subservient thereto; for (as is before noted) piety (rather than Science or prudence) does Commend a man as transcending other Creatures: Tis this that Sets him furthest from a brute, which hath no Sentiment of a deity; and therefore why not mans Essentiall difference. tis this that doth advance men to a nearer approach to the Angelicall nature, yea to the holy God himself.

Conscience, that makes a man all beasts Surmount,
we well among the Cheiffest powers may count

And thus much of the primary facultyes of the Soul Intellect will and Conscience.

2. The Secondary facultyes of Man are his propertyes arising from his Difference (Supposing it to be rationality, as is commonly Said) are Speach, Admiration, humane passions, and Laughter.

1. Speach, or the power of Speaking, is that whereby a man can with articulate Sounds of the Voyce make known the [inward] Sentiments of his mind. or rather more Generally thus; a power to impose Signifycation on outward, and Sensable things thereby to Express inward, and Secret thoughts, and this Seames to be right, because.

1. It [includes] writing and all other Signs by agreement among men which do as well attain the End of Speach as, [the] articulate words.

2. It Excludes what answers not the End of Speach. as [94]

1. Parrotising, or the Immitation of articulate Sounds as in parrots, and other birds for that they have no designed Signification.

2. All naturall voices of brutes, as having no Arbitrary Institution or imposed Signification.

3. The words of Common Lyars, who have lost their Credit, for they have no Certain or knowable Signifycation. These therefore that do abuse this faculty, have in Effect lost it.

Speach writing Signs are mans [propryety]
N'ere had by birds is lost by men that ly.

2. Admiration which I take to be the next power to this of Speach, which though it be the Daughter of Ignorence, yet it is the mother of Science. for it intimates a desire of knowledge, and prying into that which we wonder at. There is a Shaddow of it in brutes starting or Surprise which are but the Acts of Suddaine, and uncertain fear and therefore differs from this in man which is more deliberate.

3. All the Humane, and proper passions Such as Gratitude commiseration, Indignation, etc: which bespeak Somthing of morality in them.

4. Laughter the Expression of mirth, by Contraction of the face muscles, and weeping the Expression of Greife, by Compressing the Grandules, in the Inner corners of the Eyes, and thereby Shedding teares. These 2 are the most common instances of humane properties but it Seams with no great reason, for Doggs shew the former, and a Hinde or do Hunted down the Latter, and perhaps some other brutes who can Express these and other passions as Anger, fear, Greife, etc: Signally in their very countenance. Besides Suppose they ware peculiar to man; these only Express passions which belong to the Sensative appetite (Except the Laughter which arises from contempt. or that weeping which comes from Shame [and] disgrace,) [whereas] the other properties (before mentioned) have in them Signall Stamps of reason; I take these therefore to be meane if any propertyes at all. As for the Addition of these words (in a humane face) Used in the Deffinition of Laughter, tis ridiculous, and Imports that [the] humane face is rather the property than Laughter.

Admiring humane passions propertyes,
Laughter, and weeping Seam Communities

We have done now with Naturall bodyes both [in] Generall and Speciall distributively taken. We come now to the Same taken Collectively, in one mass or [Compass], Called World.

Chapter 31

Of The World

THE world or Universe is distinguished into
{Intellectuall or Invisible—of Angels,
{Aspectible, bodyes—of this here.

It is not directly a Subject of Physicks or any other Science because it is an Aggregate, or being by accident. Its defin'd an Aggregate body, consisting of Heaven, Earth, Elements and all other naturall bodyes disposed togather in the best order.

Of this Consider the Principles, and affections.

1. The Principles (analogically So cal'd) Speaking of it (as it were) a Physicall body. Internall Externall.

1. Internall, matter, and form.

1. Matter, Aggregate all natturall bodyes.

2. Form, not one Soul of the Universe diffused throughout all its parts (as the Platonists would have it) but Such as is convenient for Such an Aggregate matter, Namly naturall order between all these bodyes.

2. Externall Efficient, and End.

1. Efficient, God who created all things out of nothing, not (as Epicurus would have it) the Casuall Concourse of Atomes rolling about in the Abyss, for (Say they) two of them meating hitched togather, they rolling further met a third, which was allso affixed to them, these a fourth, etc: Still increasing (as a Snow ball) by tumbling further, but that So beautifull and wise a Contexture Should come forth thus by Accident is Such an Idle Conceit that a man may as well think that Stones, timber, tyles, etc: Should roll, by Chance into a beautifull Structure; or that printers letters Cast up in the Air would fall down into Such an Order as from them we might read an Ingeneous poem.[1] Others have thought that the wo[r]ld

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[1] The creation, duration, and end of the world, old problems all, were peculiarly the concern of seventeenth-century thinkers. Scientists, literary men, and theologians were alike anxious to defend theistic first causes against the "modern Epicureans," by whom were meant Gassendi and Thomas Hobbes; while even Sir Isaac Newton gave of his enthusiasm to the interpretation of the apocalyptic writings. The full story of the innumerable attacks upon the elusive Epicureans, i.e., materialists, is still to be written. Some hints may be gained from J. M. Robertson, *A Short History of Freethought Ancient and Modern* (2nd ed., London, 1906), II. 60–125; G. D. Hadzits, *Lucretius and His Influence*, pp. 284–317; and L. I. Bredvold, "Dryden, Hobbes, and the Royal Society," *Modern Philology*, XXV. 417–438. For an introduction to the enormous literature on

might have no beginning, or been from eternity, but if So there must be two Infinites, God, and the world, which is absurd; again if So, then there must have been a multitude of men before Adam, as well as other things: and then Supposing them to [have been] of the Same kind, and inclination with other men who we see love to communicate the hystory of their [own] times to [posterity], we had then Surely had the hystory of their times infinitely before the present date of the world; and the 764 Imaginary years of the Julian period, had not only been reall time, but they and Infinitely more before them had been filled with noble actions; and then also had all arts, and Sciences had their perfection infinitely Sooner, and not grown by degrees as we see they do. God indeed could have created it from Eternity, but the world could not be from eternity: The Active [95] power was Sufficient for it but not the passive; we may therefore conclude with the Schoolmen, that newness of being (or to have a beginning) is necessary to the Creature, and if a beginning then [a] Cause, and that not itselfe (which could not act before it was) nor any other thing except God himself, who has no Cause nor beginning, for if any other thing which had a beginning was a Cause, then that also must have its Cause and So onwards Infinitely, which in ratiocination is absurd.

Not atomes rolling concurrs World forth brings
Nor Can Externall be Created things.

The Efficiency of God in respect of the world is Creation, and that
{Primary or
{Secondary.

1. Primary, a production of all things out of, or rather from nothing. The term nothing being considered not as matter, but as a term from which, as Privation is in Generation; So he produced the Chaos, or first Confused or inordinate matter.

2. Secondary, out of inhabile or unapt matter, as man out of Earth woman out of man; and this also is creation because exceeding the power of nature, and therefore requiring an Infinite power to affect.

Chaos at first; then [Species] which we See.
Which by the power of nature could, not be.

2. The End of the World is 2 fold, Primary, and Secondary.

1. Primary Gods Glory: for the Invisible things of him from the Cre-

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the duration and end of the world, see the articles on Chiliasm, Eschatology, and the Millennium in any good encyclopaedia.

ation of the world are Clea[r]ly Seen being understood by the things that are made even his Eternall power and Godhead, (Romans. 1. 20.)

2. Secondary, is the Use of man, (Genesis. 1. 28.) have dominion over it, (and verse 29.) behold I have Given you Every herb, etc:

Worlds matter aggregate form order is
Maker God; End his [Glory], and mans bliss.

and thus of the principles of the world.

2. The Affections are Usually reckoned, 5. Unity, Locability, Duration, contiguity perfection

1. Unity, for though God by his absolute power could have created more such worlds, yet tis probable he did not; because this one is Sufficient for the Ends, (Gods Glory, and mans good.) And if it were granted that the moon and all other planets, except the Sun, were not only habitable, but inhabited, as this our Earth is, yet this would not make a plurality of worlds; because the Earth, planets, and fixed Stars altogather make but one world. Those places, (Hebrews. [1. 2. and] 11. 3.) that mention worlds as made (Κοσμια) are Spoken of the parts metanimically having the name of the Whole from their adornment which the aforementioned Greek-word Signifyes. So that they are to be understood thus; all the adorned and beautifull creatures were made of what did not appear, or nothing, for of not being and not appearing is the Same reason or we make the Same account.

One world therein all bodyes doth comprise,
and to Answer Gods Creating End Suffise

2. Locability (in Power) though not Locality (in act) as to Externall place there being no other body containing or Adjacent. Internall place it has namely the Space it does possess, but instead of the Externall is the Abyss, or Imaginary space, or rather the Infinite presence of God.

Internall place unto the world there is
Externall none; unless it be th'abyss.

3. Duration unknown to man.

1. As to the present State of nature men are apt to enquire of this or any other hidden knowledge; the Jews had a Conceit of 6000 years and then the 1000 Sabbatism; applying that of the Psalmist 1000 years are in thy presence but as yesterday, (Psalm 90. 4) hence they inferr that 1000 years are answerable to a day, and So the world to last a Week of Such dayes, but here are too many presumptions for faith or reason to assent unto.

Others have allowed unto the world 33 Jubilees (of 50 years) for the Christian religion to remain on the Earth because Christ lived 33 years in the dayes of his flesh; and then it Should have Ended anno 1650. Which being past this Conceit is Experimentally confuted. A more Ingenious conjecture is that of Dr. Power[1] taken from the motion of the Suns Apoge, which is but 1 degree. 42. 33.″ in [100] years. now this revolution will not be accomplished in less than 20000 years therefore so much he assigns to the world, whereof about 5000 years are past, and about 15000 yet to come; for he Supposes that the wise oppificer will not distroy his fabrick till every wheel has had its round once at least. But waving these conceits of men we should have regard rather to Scripture which plainly tells us it is not for us to know the times which he has put only in his own power (Acts. 1. 7.) And again Of that day and hour knoweth no man nor the Angels in heaven, nor the Son (as man by humane ordinary knowledge) but the father (Mark. 13. 32.) yea it ware better for us (leaving Secret things with God) to mind our personall frailty, and prepare for our own dissolutions, and departure, out of this world, for then the world [will be ended for] us, how long [96] soever it Lasteth after us. Only Sure it is that the world will continue till all the Elect be cal'd; but who they are, and how many, and in what Ages they Shall live can only be Known to God.

2. As to the future State of the Universe after the Dissolution of the present form and Matter diverse conjectures also have been made. Some have thought, it shall be totally Annihilated, Others that the last conflagration will be only a purgative fire of the Dross, and Vanity to which the whole groaning creation was made subject by the Sin of man; and that the raised, and Glorifyed bodyes of Saints shall have their happy residence in this purifyed world; being by this refining rendred the new heavens and new Earth, which are promised to come and shall abide for ever. But I doubt in this matter also the Scripture light is not Sufficient to make Such conjectures Satisfactory. On the whole it is best for us to be wise unto Sobryety, not pretending to know more than is intelligibly reveallled to us, tis enough to beleive that Glorifyed bodyes shall have a Glorious State adapted for them where so ever it be.

The worlds duration is a thing conceal'd
We are Allow'd to know but what's reveal'd

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[1] In addition to comment on the matter in his *Experimental Philosophy*, Power wrote a manuscript "Essay on the World's Duration," now in the British Museum. See the article on Power in the *Dictionary of National Biography*, and compare with the note on p. 51, above.

4. Contiguity of parts So that there is no Vacuum (or Empty Space) therein. Tis better methinks to allow Cartesian Subtile matter, than the Atomists intersperced vacuityes, to Solve the doctrine of Locall motion. The matter of Light and fyer we See can penitrate where air cannot, and therefore the Subtile matter being the Same or like it may Every way Give place to, and Immediatly follow a [removing] body, [without] penetration of Dimensions.

Vacuum abhorr'd, all motion Solve you may
by Subtile matter yealding every way.

5. Perfection, both of parts, and Vertues.

1. Of parts [their variety] being a Sufficient number of Species or Kinds, the Individuall Souls are dayly [c]reated anew yet they are no new Species, the Extraordinary, and miraculous works that are Somtimes Seen are not to be [reckoned] as Species of nature, or additions to the world but new creatures of Gods immediate power [produced] for the Same End for which the world was made.

2. Of Vertues, their degrees assigned to Every Creature; So that tho we may fancy greater perfections, (as that man Should fly as birds dive as fishes, be Invisible as Angels etc:) yet in reallity these would not be mans perfections because the Infinitly wise God has ordered for Every Thing what is best; his will and wisdom being the measure of all perfection.

The World of parts perfection is Possest.
and Every part of Vertues which are best.

Now of him, and through him, and to him are
all things [to whom be Glory] for Ever. Amen.

TRANSCRIPTUM, ET FINITUM.
OCTOBER 3. ANNO. 1697.
PER ME D: G:

Appendix

Appendix[1]

An Extract out of Doctor John Wallis his Hypothesis concerning the Ebbing and Flowing of the Sea. In His Letter to Mr. Boyle Dated Aprill 25. 1666. Inserted in the Philosophick Transactions No. 16 page 263. Drawn out by C.M. to be added by way of Appendix to our Phisicks.

THE Periods and Magnitudes of Tides doe So constantly attend the moons motion that we may well presume they are either governed one by the other or both of them by some common cause and So there must be a certain connection between them.

The Moons occult quality to influence moist bodies Leaves us in the Dark as to this matter and only confidently assumes that it is So without Shewing us how or why: the magnetick vertue fancied to be in the moon whereby it Should draw the water to it or drive it from it does as Little Satisfy for drawing to would make it always high water where the moon is verticall; and driving from or depression by certain gravitating emanations would make it (on the Contrary) always Lowest water at the Same time of verticity: but both of them are false. The Dr. therefore Layes aside Such Hypotheses and closes rather with Gallileus referring it to the Earths motion according to the generall Laws of motion and the Statick principles; Onely he notes in Gallileus a defect of the true history of tides which is a blemish on So excellent a person or a prejudice to the maine Hypothesis; This defectiveness of the History Still remaining in great part; He therefore proposeth his own Supposall onely as an essay to be farther considered which is this. That the Earth's motion causes the tides and the Moon's Phases Determine (or rather point out) their periods. Of Tides Some are extraordinary (Either from Some accidentall cause or the naturall not Sufficiently observed) others are ordinary and constantly taken notice of: Tis of the Latter he offers to give the Reason. These are 3 Diurnall Menstruall and [2] Annuall.

1. Diurnall Reciprocation is twice in Somewhat more than 24 hours.

2. Menstruall has two considerations of the time and of the magnitude.

1. The Time that the tides remove round the day and night in one Synodicall period of the moon as if at full moon (at any place) it be full Sea

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[1] From the Rogers MS.

at noon this Day tomorrow it will be full there a Little before one the Next near two (Loosing near an hour every day) till at the next full Moon twill be full Sea again just at noon as it was before.

2. The Magnitude is, that about the full and new moons the Tides are highest and the Ebbs Lowest; that at the Quadratures are Least tides and at the times intermediate they rise proportionably: This variety is expressed by Spring and neap tides.

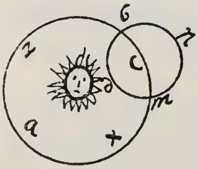
3. Annuall that twice in a year the Springs are Higher than at other times. These times were formerly Said to be near the Equinoxes but indeed by better observation they are found to be in the begginning of February and November. To Solve these Phainomenas he assumes Divers things with Gallileus which either will be readily granted or are elsewhere proved, as

1. That a body in motion is apt to continue its motion in the Same velocity unless hindered by Some other body as a body in Rest will continue in rest unless it be put into Motion.

2. That fluids do not perfectly recieve their change either to Rest or motion from their conteining vessels but upon the vessels change the fluid rises at one or other end above Level for a while and then falls back again into Level by its own gravity.

3. That the Seas are but as water in Large vessels and the vessels of Earth being carried about Swifter or Slower at divers times the water is not So fastned to the Earth but that at the acceleration or retardation of that part of the Earths Surface where the water Lyes it will Swell up for a time at one end before it can recieve the Same degree of motion with its vessel.

4. He assumes also the Earths Double motion. Annuall about the Sun and Diurnall about its own axis or Center. He allows (with Gallileus) the annuall to be about 3 times as Swift as the Diurnall in its æquator or other great circle; and that therefore a Superficiall part of the Earth adds to and takes from the annuall Swiftness of its Center according as that part comes nearer to or goes farther from the Sun. As Suppose (c) the Center of the Earth move equally in the great orb about the Sun (c. x. a. z.) yet the point (b) in the Surface rolling about to (d. m. n.) will alter its pace for in the day time at (d) the part will take from the Swiftness of the centers motion because tis moving the contrary way but in the night time when the [3] Same part comes to (n) it adds to the annuall Motion of the center because its revolution is the same way and has a compound motion both of the annuall and diurnall: whence it follows that the Superficiall part (b)



moves Slower in the day and Swifter in the night and by consequence the Sea must be affected with these changes of velocity So as to make two tides in about 24 hours. And thus far the Dr. agrees with Gallileus. But then (Saith he) all this would give the tides at that place of the Surface onely and always at the Same times (noon and midnight) every day and not make them Shift round in a month as we see they do. To Solve this *Johannes Baptista Ba[li]anus*[1] (vid. Ricc alm: novum page 216)[2] makes the Earth but a Secondary planet to the moon and to move about it while the moon goes about the Sun contrary to what is commonly Supposed that the Earth goes about the Sun and the Moon as a Secondary about the Earth. this (though it might Serve for a menstruall period of tides) he admitts not because The Earth is bigger than the moon (as Jupiter is than his Satellites and Saturn than his) and therefore twere Less Consonant with the generall System of the World that the Less body Should carry about the greater with it: As the Suns Motion about its axis is (with good reason Saith he) judged to be the Phisicall cause of the primary planets moving about so tis Likely the rotation of Jupiter (discovered Lately by its fixed Spotts) is the cause of its Satellites motion about its body; and So also the Earths dayly revolution does more Likely carry about the Lesser moon which does not So revolve as appears by the Same face always towards us. If it be Said this happens because the moon carries about the Earth in just the Same period in which it turns about its own axis This is contrary to that of the Suns carrying about the other planets or Jupiter carrying about his Satellites for in these the Mover turns his period Sooner than any of those that are moved do accomplish theirs and thus he refells *Ba[li]anus*.

N.B. I must confess I am not So well Satisfied with his Second reason as to think the Sun has So powerfull a Vortex; or if it have I See not why it Should cause revolution in the planets about their own axis (as tis Said all the primaries do). The Sun might indeed Swim them round about himself; but this would not turn them about themselves also and therefore I rather incline to admitt Gallileus notion of their being created at Some Distance from their place and then dropt trolling into it. But this only by the by.

Ba[li]anus his fancy being rejected the Doctors Surmise (as he is pleased to call it) for the Solving of this Phainomenon is, That the Earth and Moon are connected (whether by Magnetick or other [4] Tye matters not to the present purpose) So as the Earth is the center of the moons periodicall motion in 27 dayes And that these two together may be accounted as one aggregate of bodys having one common center of Gravity which (according to the Laws of Staticks) is the Line connecting their Respective centers So divided that its parts be reciprocall proportionable to the gravities of the 2 bodies. As Suppose (with the Learned Hevelius in his Selenographie, out of Tycho)[1] the magnitude (and therefore probably the gravity) of the Moon $\frac{1}{41}$ of that of the Earth; and Suppose (with them) the mean Distance of Centers to [be] 56 Semi Diameters of the Earth; then the Distance of the Common Center of gravity from the Center of the Earth (the bigger body) will be about $1\frac{1}{3}$ of its Semidiameter that is a third of a Semidiameter from the Earths Surface in the air Directly between the Earth and moon. This common Center of Gravity is next Supposed to move in the great orb about the Sun (whither a true Circle or an Ellipsis is not now to be enquired) and this in the annuall period; but the Earth meanwhile is to roll round about its own axis dayly and its Center is to go about the common center of gravity (as in an Epicicle) in the time of the Moons period; and this revolution of the Earth about the Common Center of gravity gives the monthly inæqualities as the daily revolution does the Diurnall. (a) The Center of the Earth: (b.c.d.) the revolution of the Earths Surface daily: (C) the Common Center of gravity: (f.g.h.) the revolution of the Earths Center about the Common Center monthly: (i. k. l.) the Moons Monthly revolution about the Same common Center which though it Serves for the distinctions of Seasons in the month yet it is not concerned in the business of acceleration or retardation of the Earth and So causing Tides only because of its Synchronism it may tell us when the Spring and neap tide will be.

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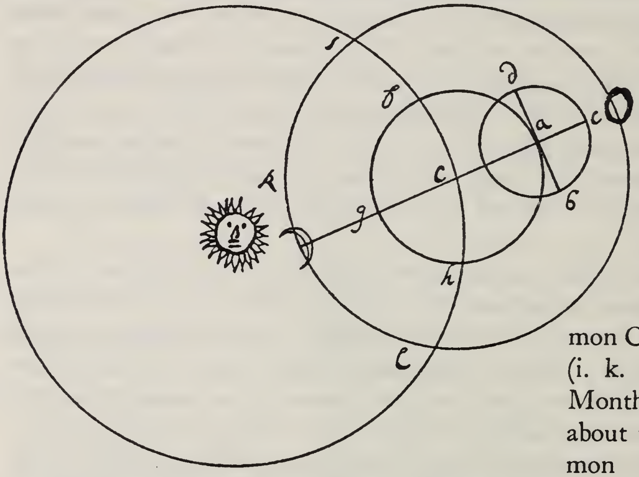
[1] Giovanni Battista Baliano (*d* 1666) was an Italian physician and mathematician.

[2] The reference is to Giovanni Battista Riccioli, *Almagestum Novum* (Bologna, 1651).



N.B. Both the Distance of the Common center and the great orb about the Sun in which the Center is [5] Supposed to move is far Less than it Should be if the paper would contain it. Onely this is Sufficient to Shew that when tis new moon and the Earth is beyond the common center of gravity farther from the Sun then is the greatest acceleration because the Earths Center goes the same way with the Common Center in the great orb: but when tis full moon and the Earths Center is at (g) moving towards (h) then is the greatest retardation because then it moves towards (h) the contrary way to the Common Centers motion in the great orb.

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[1] Johann Hevel, *Selenographia sive Lunae Descriptio* (Danzig, 1647). The information here, however, is in Wallis's article.

Having thus Endeavoured to account for the Diurnall and menstruall Periods of tides he comes to (that most obstruse point of) the Annuall highest Spring which must be from the former causes Somewhat augmented in those times of the year wherein Such great tides are found. The times in the open Sea (as at Rumney marish) are 2 the highest Springs are in the beginning of February and November (Cold Candlemass Stream and Allhallows Stream) which Seems Strange for that they are none of the remarkable times of the year (as the Equinoxes Solstices Apoge and Perige of the Sun) Nor opposite parts of the year there being but 3 months between them on the one Side and 9 on the other. After Long wonder in this part he at Last (in the year 1664) thought that the inæquality of naturall Dayes (or the 24 hours from noon to noon) might be the cause of this which he thus Explaines. Everyone knows that the artificiall days from Sun to Sun are unæquall and Astronomers know (what is not noted by others) that the naturall dayes of 24 hours from noon to noon are unæquall also for this naturall day is measured not only by one intire conversion of the Equinoctiall (taken to be performed in æquall times) but increases So much as the Sun (or Earth) moves in that time (of 24 Equinoctiall hours) in the Ecliptick according to the annuall motion (which is one degree or one $\frac{1}{15}$ of an hour more or Less) for when that part of the Ecliptick which was yesterday with the Sun at our meridian comes thither again today tis not yet noon because the Sun is not now in the Same place of the Ecliptick it was yesterday at noon; but gone Eastwards about a degree, and therefore he hath one 15th of an hour yet [6] To Spend in going on westward ere he comes to our meridian and So make it noon. This Shifting of place by a planet is most observable in the moon which passes on about 12 degrees Eastward every 24 hours. Now this addittament to the 24 Equinoctiall is unæquall upon a double account.

1. The Sun in Apoge and Perige dispatches not æquall arches of the Ecliptick in the Same time; but greater near the Perige (about the middle of December) and Less near the Apoge (About the middle of June) as appears by the Suns annuall motion.

2. Æquall Arches of the Ecliptick by which time is measured (if the Sun did move æqually in it) do not answer to æquall arches of the Equator because of their obliquity one to the other: for in the Solstices where the Equator and the Ecliptick are near paralel an Arch of the Ecliptick (say 10 Degrees) will be near æquall to an Arch of the Equator of the same number: but near the Æquinoxes (where the intersections of these two arches are) Such an arch of the Ecliptick will not require above 6 or 7 degrees in the Equator to answer it: i.e. a meridian drawn to cut 10 degrees in the Ecliptick continued on will cut but 6 or 7 in the Equator (as in the Table of the Suns right ascension and on the globe is easily Seen). According to the former of these causes (if it did operate alone) we Should have the Longest days in December and the Shortest in June; and it would give us two annuall tides to be at those times. According to the Latter (if also operating alone) the dayes would be Longest in the Solstices (June and December) and Shortest in the Equinoxes (March and September) and So there would be 4 Annual Highwaters. But the true inæquality of Naturall Days is from the complication of both these causes Sometimes crossing Sometimes promoting each other; and this gives that (though we Should find Some increases and decreases of Naturall days at all those mentioned Seasons answerable to their respective causes and perhaps of Tides proportionably yet) the Longest and Shortest naturall days absolutely of the whole year are about those times of Allhallow and Candlemass.

FINIS

Index

Index

ACADEMIES, dissenting, xv–xvi, xviii
Acid, 159; liquors, 101; salts, 49; taste, 177
Agaric, 142
Agate, 115
Agricola, Georgius, 118 *n*
Agriculture, 74, 75; draining of bogs, 70; improvement of land, 116; and physics, 3, 5
Air, 47–52; cause of earthquakes, 98; cause of variety in temper of, 27; changes in, 28, 29, 137; condensed, 181; conveyance into mines, 118; home of birds, 197; home of spirits of brutes, 189; humidity, 41, 47, 53; in lungs, 131, 192; medium of light, 155, 156, 160; medium of sound, 87, 163, 164–169, 172, 173, 188; navigation of, 191; surrounding the earth, 20, 21, 40, 47–48 (*see also* Atmosphere); tenuity, 38; three regions of, 47–49, 100; transmutation of water into, 41; vacuities in, 39; weight, 49, 50–52, 76, 86; wholesomeness, 52, 86, 168
Air pump, xvi, xxxi; experiments, 43, 48 *n*, 50
Alabaster, 115
Alchemists, on the soul of metals, 120–121
Alchemy, 121, 123, 125, 201
Ale, difference from beer, 56
Alkali, 55
Allen, James (*d* 1710), xxii
Alloys, in gold coins, 119; in silver, 122
Alum, a middle mineral, 125; use in coloring water, 125; in dyeing, 159
Amber, electrical property, 76
American Antiquarian Society, xxxiii *n*, xxxiv, xxxv
Amethyst, as preventive of drunkenness, 114
Amulets, 174
Anatomists, 132; on nerves of sense, 178; on parts of the human body, 198; on seminal organs, 143; on time of the pulse, 192
Anatomy, 4, 126 *n*; of the brain, 152; of the ear, 166–167; of the eye, 152–153
Andros, Sir Edmund, xxii
Angles of incidence and reflection, 48–49, 84, 109, 157, 166, 167
Animal secretion, 128
Animal soul, 144, 145–146, 149, 180, 181, 187 *n*, 188–190, 196 *n*, 197, 199
Animal spirits, 44, 52, 114, 129, 135, 138, 170, 171, 174, 175, 181, 182, 183, 187, 189, 192, 194
Animals, 40, 53, 83, 86, 98, 149–151, 152–205; distinction from plants, 135; division into man and brute, 7, 10, 79, 126, 127, 149, 196–198; growth, 134–138; procreation, 143–148
Antimony, use in manufacture of bell metal, 122, 124, 125
Antiperistasis, 47, 48 *n*, 49, 81, 83, 85
Ants, 196
Apogees, 23
Apples, 140
Apricots, 140
Aqua fortis, use in dissolving metal, 122
Aqua regis, use in dissolving and testing gold, 119, 121
Aquinas, St. Thomas, xxxvi *n*, 185 *n*
Architecture, relation to music, 171, 172, 201–202
Aristotelians, xxxvi–xxxix; on cold, 42; on sand, 38
Aristotle, xxxvi, xxxvi *n*, xxxvii; definitions: of color, 158; of efficient, 16; of external place, 16; of light, 155; ignorance of tides, 62; on intelligences of heavenly orbs, 21, 25;

Aristotle (*continued*)
logic, 10 *n*; pronouncement on heavenly body, 20; on mixed body, 78; on regions of air, 48 *n*; on souls of brutes, 188; system of the world, 21–22; writings relevant to Morton's discussion, 7 *n*, 9 *n*, 20 *n*, 36 *n*, 42 *n*, 61 *n*, 73 *n*, 78 *n*, 81 *n*, 94 *n*, 100 *n*, 108 *n*, 126 *n*, 134 *n*, 149 *n*, 152 *n*, 163 *n*, 174 *n*, 180 *n*, 187 *n*, 194 *n*, 196 *n*
Arithmetic. *See* Mathematics
Arsenic, 125; steams, 87, 125
Asafœtida, 175
Ash tree, source of manna, 105; use in musical instruments, 164, 166
Astrology, 28–30, 35
Astronomy, 28 *n*, 33; advance in, 20, 23, 93; astronomical time, 217; use of eclipses in, 34–35. *See also* Earth; Moon; Sun, etc.
Atmosphere, 86; extent, 48, 85, 93; relation to trade winds, 94; steams, 49, 50; temper, 104; weight, 51, 52, 59
Atomists, xxxix; on fluids, 38; on matter, 36; on vacuities, 210
Atoms, 15, 18; magnetic, 75–76; not the origin of world, 206
Ayer, Obadiah, xxxiv
Azimuth circle, 92

BACON, FRANCIS, xxxvii, xxxix, 118, 163 *n*
Bagpipes, 149
Bailey, John, xxii
Baldwin, Christopher Columbus, xxxiv
Baliano, Giovanni Battista, 215, 215 *n*
Ball, Sir Peter, 167, 167 *n*
Barbecuing, 127
Barometers, 51, 52
Barometric pressure, 48 *n*
Beale, Bartholomew, xxxiii, xxxiii *n*
Beale, John, 28, 28 *n*
Beavers, 197
Beer, brewing of, 56; spoiling by thunder, etc., 168; time of fermentation, 82; weight, 60
Bees, 105, 196
Beeswax, 55
Bell metal, 122, 124, 125; springiness, 164
Bellows, use in kindling fire, 43; in ventilating mines, 118
Bible, quoted or alluded to: on animal soul, 188; on astrology, 29–30; on chaos, 13; on confusion of tongues, 32; on Copernican scheme, 24; on dew of youth, 136; on division into heaven and earth, 20; on duration of the earth, 74; on duration of gold, 119; on hailstones, 103; on influence of heavenly bodies, 27, 28; on naming of ships, 82; on privation, 10; on procreation, 143, 144; on the rainbow as the seal of God's covenant, 109, 111; on the sea, 61; on the soul, 11, 145; on springs, 70; on study of natural philosophy, 4
Biddle, John, xvii
Birch, Thomas, 28 *n*, 48 *n*, 167 *n*
Birdlime, 39
Birds, 21, 23, 182, 210; carnivorous, 127; growth, 136; hibernation, 192 *n*; imitation of sounds, 205; song, 170
Birthmarks, 144
Blackstone, William, vii *n*
Blake, James (*d* 1771), xxxiv
—— Samuel (*d* 1715), xxxiv
Bleeding, use and danger in medicine, 133
Blindness, 9–10; touch a substitute for sight in, 177
Blister, use in medicine, 133
Blome, Richard, xxxviii, xxxviii *n*, 7 *n*
Blood, circulation, 45, 131–132, 144, 152, 192–193, 194; composition, 128, 129, 131, 143; distinguishes perfect from imperfect brutes, 196; fermentation, 133; heat of, in animals, 197; similarity to yolk of egg, 147
Bloodstone, medicinal use of, 114
Bodleian Library, xxxiii
Borelli, Giovanni Alfonso, 187 *n*

Boston Public Library, xxxiv
Botany, advance of, 4; subjects treated in, 142. *See also* Plants; Vegetables, etc.
Boyle, Robert, xii, xxvi, xxviii, xxxix, xxxix *n*, xl, xl *n*; on circumference of the earth, 32 *n*; on cold, 107; on color, 111, 159, 160; on fluids, 36 *n*; on form, 11; interest in process for sweetening salt water, 71 *n*; interest in star-shoot, 83 *n*; letter to, from John Wallis, 213; on mines, 117 *n*; on the origin of gems, 115, 115 *n*, 134; on the spring of the air, 164; on time, 17; writings relevant to Morton's discussion, 32 *n*, 36 *n*, 42 *n*, 43 *n*, 48 *n*, 61 *n*, 73 *n*, 81 *n*, 100 *n*, 108 *n*, 113 *n*, 133 *n*, 152 *n*, 164 *n*
Bradstreet, Simon, xxviii
Brahe, Tycho, 20 *n*; on comet of 1577, 92, 92 *n*; on magnitude of the moon, 216; on system of the world, 21, 23–24, 25 (fig.)
Brain, anatomy of, 152; animal spirits, 174, 183, 187, 194; effect of odors on, 174–175; formation of ideas, 200; making of images, 151; operations hindered by sickness of body, 28; relation of nerves to, 152, 177; seat of common sense, 161, 164; seat of interior senses, 180, 181, 182, 183; temperament, 183, 199
Brandy, use in coloring water, 101
Brass, composition of, 124, 125; instruments of, used by Phoenicians, 123; springiness, 164; use in making pewter, 122; weighing with, a test of gold, 121
Brattle, Thomas (*d* 1713), 161 *n*
—— William (*d* 1717), xxiii, xxiv, xxviii
Bread, 174, 180; making, 56–57
Breathing. *See* Respiration
Brewing, 55, 71
Brimstone, 102, 122, 125
Briony, 136
Britain, origin of name, 123
Brooke, Christopher, xiv
Brown, John (*d* 1742), xxxv
Browne, Thomas, 52 *n*
Bunyan, John, xvii *n*
Burning glass, 43, 157
Burning lances, 85
Burton, Robert, on anatomy, 126 *n*; on circumference of the earth, 32 *n*; on "neoterics," 134 *n*; on physiology, 174 *n*; writings relevant to Morton's discussion, 149 *n*
Bushell, Thomas, 118, 118 *n*
Butler, William, 120, 120 *n*
Byles, Mather (*d* 1788), xxxv

CABBAGE, destruction by vine, 140
Calamine stones, 124, 125
Calamy, Edmund, vii *n*, xiv, xiv *n*, xv *n* xvii, xvii *n*
Cambridge Ministerial Association, xxv; issues "Proposals for Recording of Illustrious Providences," xxvii–xxviii; on spectral evidence, xxvii
Capillary vessels, 45, 131
Cardan, Girolamo, 58 *n*
Cartesians, xxxvii–xxxix; on animal soul, 149 *n*, 180 *n*, 196 *n*; on effluvia, 161 *n*; on gravity, 73; on matter, 210; on pineal gland, 199; on vortices, 20 *n*. *See also* Descartes
Cassiopeia, new star in, 92
Castor and Pollux, a fiery meteor, 82
Cats, growth of, 136; light reflected by eyes of, 127; unfit for human food, 84
Caverns, water in, 62, 70; wind in, cause of earthquakes, 98, 99
Ceterach, 141
Chaderton, Lawrence, vii *n*
Chalk, use in improving land, 116
Charleton, Walter, 128, 128 *n*
Chasm, an appearing meteor, 108, 109
Chemistry, advance in, 4; analytical methods, 83, 142; coloring infusions, 101; matter, 36; metals, 75, 118, 122, 123, 124; odors, 174; vinous spirits, 83
Chrysolite, 115
Chyle, circulation, 194; preparation, 127–130

Chyme, preparation, 130–131; quality, 129
Civet cat, 175
Clamminess, a second quality, 39, 56, 76, 113
Clark, William (*d* 1684), 81 *n*
Clarke, Samuel (*d* 1683), vii *n*
Cleaveland, Parker, xxxiii
Climate, influence on growth, 136. *See also* Weather
Clocks, motion of, 14, 16, 149
Clouds, 100; about the sun, 20; appearance of, with burning lances, 85; carriers of rain, 85, 86, 141; cause of darkness, 103–104; cold, 85, 86, 94, 111; Milky Way appears like, 31; parting of, a cause of sound, 164; place, 47, 48, 90, 94; prognosticated by conjunction of moon and Saturn, 28; reflection by, 108–111; source, 96; source of snow, 102–103; source of star-shoot, denied, 84; source of thunderbolt, 87
Cloverseed, 142
Coal, 43, 44, 104
Codling, 139
Cogitation, 181, 200, 201
Coinage, of gold, 119, 121; of copper, 124
Cold, a first quality, 37, 41, 42, 51, 53, 73, 78, 79, 80, 141, 177; cause of gravity, 39; effect on thermometers, 50
Cole, William, 128, 128 *n*
Color, xxxi; cause of, 158–160; of the eye, 153; of the face, 79; of light, 89; of plants, 142; of the rainbow, 110–112; of the yolk of eggs, 147; perception of, 150, 151, 183, 200
Columella, Lucius Junius Moderatus, 70, 70 *n*
Comets, 89–93; location, 20; not fiery meteors, 88
Comfery, 140
Common sense, 151; function of, 164, 180–181; obstruction by sleep, 194; seat of, 161, 164
Compass, boxing the, 94 *n*, 97. *See also* Loadstones
Concoction, 127, 129, 130, 131, 132, 133; of manna, 105; of prolific seed, 143
Conscience, in animals, 196; definition, 204
Constellations, in astrology, 29; influence in locating mines, 117; number and names, 31
Contemplation, 183; difficulty of, 202; the end of science, 3
Convolvulus, 136, 137
Copernicus, 20 *n*; on the ecliptic, 68, 69, 76; on motion of the earth, 91; on tides, 62; hypothesis of, 63; scriptures used against, 24, 74; system, 21, 22–23, 25 (fig.), 32, 64
Copper, 119, 123–124; use in making brass, 125
Cork, buoyancy, 54; levity, 44, 50; rarity, 38
Corn, diseases of, 104, 105; effects of wind on, 158; preparation of soil for, 116
Cornwall, diamonds, 115; fiery meteors seen in, 87; stones found in, 116; tin mining, 115, 117 *n*, 118, 122, 123
Corpuscularianism, xxxix, 15, 36, 145. *See also* Atomists; Atoms
Corruption, ancient doctrine of, 13–14, 17–18, 78; caused by thunder, 87; in heavenly bodies, 20, 21; of popery, 203; of the soul, denied, 188, 190
Counterfeiting, 121–122
Cowles, Thomas, 52 *n*
Cox, Daniel, 116 *n*
Crabs, 197
Crassitude, a second quality, 38, 43, 82
Creeping, 190, 191
Crickets, 196, 197
Crocodiles, 197
Cromwell, Oliver, xii, xiii
Cruso, Timothy, xvi
Crystal, 115
Crystalline sphere, 21, 22, 24 (fig.), 31

INDEX

Culpeper, Nicholas, xxxviii *n*
Curwin, George (*d* 1717), xxxiv

DANCING, 191; tunes for, 172
Darnel, 140
Dart, a fiery meteor, 97
Deal, use in musical instruments, 164
Death, 10, 17, 126; sign of, 163
Dee, John, 28 *n*
Deer, motion of, 190; shedding of tears by, 205
Defoe, Daniel, xvi, xvii
Density, a second quality, 38, 177; effect on light, 160
Desaguliers, John Theophilus, xxxi
Descartes, René, xxxvii–xxxix, 15 *n*, 113 *n*; on animal motion, 188; on color, 108 *n*; on earthquakes, 94 *n*; on external place, 16; on matter, 36; writings relevant to Morton's discussion, 11 *n*, 36 *n*, 81 *n*, 186 *n*, 187 *n*. *See also* Cartesians
Devil, xxv, xxvii, 143; part played by, in astrology, 29; part played by, in dreams, 195; power over preternatural fiery meteors, 87
Dew, 103, 104–105; lack of, on high mountains, 48; steamy, 132
Diamonds, color, 159; shape, 134; value, 115
Diaphoretics, use in reducing fat, 138
Digby, Sir Kenelm, 28 *n*
Digestion, animal, 126–130, 137; plant, 134; a process in chemistry, 142
Disease, caused by heavenly bodies, 28, 29; cure in time of pestilence, 52; of human body, 79; of plants, 74. *See also* Medicine
Distillation, art of, 100; in chemistry, 142; in fresh-water fountains, 70; steam the basis of, 45
Dogs, blind at birth, 9; bristling hair, 158; delight in man's company, 197; growth, 136; hunting, 174; laughter, 205; motion, 188; reason in, 180, 196; souls, 149–150, 197, 199; unfit for human food, 127
Drake, Sir Francis, 74
Dreams, 194–195; use in locating mines, 117
Dry, a first quality, 37, 41, 42, 73, 78, 79; not conducive to odor, 174; preservative of spirituous matter, 141–142; relation to taste, 177; in stone, 113
Ductility, 113, 117; of gold, 119–120; of lead, 123; lacking in middle minerals, 125; of silver, 122
Dudley, Joseph, xx, xxi
Du Hamel, Jean Baptiste, xxxviii
Dunton, John, xx, xx *n*, xxiii *n*
Dyestuffs, 158, 159

EAR, agreement between eye and, in harmony, 172; anatomy, 163–164; organ of sound, 163, 173, 188; pleasure of music to, 170, 171; position of, for echo, 166–167; of Saturn, 33; strong sound harmful to, 168
Earth, Aristotelian element, 36, 42, 73; atmosphere, 48, 93, 94–95; body, 40, 53; caverns, 69–70, 98–99, 114; center, 50, 84; coldness, 42, 73; circumference, 31 *n*, 32, 32 *n*; dryness, 42, 73; figure, 73–74; gravity, 73; habitableness, 34; home of beasts, 197; influence of heavenly bodies on, 27; juices, 134–135; magnetism, 18, 75–76; magnitude, 31, 34; motion, 18, 22, 23, 24, 64–69, 93, 94–95, 213–218; a passive particle, 36, 37, 45, 55, 60, 73, 85, 113, 119; place in eclipses, 34, 74; plastic virtue, 139; pores, 70, 102; position, 21, 24 (fig.); reflection of sun's light by, 33, 47; regions, 74–75; solidity, 73; steams, 85, 91, 94–95, 103–104; veins, 117
Earthquakes, cause, 98–99; Descartes on, 94 *n*
Earthworms, 197; motion, 130, 191

Echoes, 165–167

Eclipses, of comets, 92; lunar, 33, 34; solar, 34; uses, 34–35, 93

Ecliptic, 34, 64, 66, 68, 69, 76, 218

Eells, Nathaniel (*d* 1750), xxxiv

Eels, 136

Effluvia, doctrine of, 161 *n*; of the earth, 85, 134; necessary to odors, 174

Eighth sphere, 22, 24 (fig.), 31

Elasticity, a second quality, 39; of the air, 49–50; effects of, 40; of iron, 125

Elder (shrub), 142

Electricity, 40, 40 *n*, 76

Elements, definition, 7, 20, 36–37; qualities, 37–41; union in mixed bodies, 78, 113. *See also* Air; Earth; Fire; Water

Elephants, 188, 196

Elms, 140

Embryo, 10; marks in, 144; preparation to receive the soul, 13

Embryology, 139 *n*, 146–147

Emerson, John (*d* 1732), xxiv

Empedocles, xxxvi

Epicurus, 206

Equator, difference from ecliptic, 218; greatest tides at, 65, 69

Equinoxes, days shortest at, 218; position of earth at, 65, 69; tides at, 63, 69, 217

Esculapius, 4

Ether, 21, 25, 50, 59

Ethics, 177, 186, 204

Evaporation, cause of scent, 49; prevention, 56, 70, 98; salt-making by, 61; of spirits, 194; of water, 40, 45, 113

Evelyn, John, xiv, xiv *n*

Evers, 140

Evil eye, denied, 161

Eye, anatomy, 152–155; appearance in embryo, 147; organ of sight, 160; position of, a cause of differences in appearing meteors, 108–111; position of, a cause of differences in comets, 89, 90, 92; proportion pleasing to, 171, 172; reception of images by, 183; retina, 154–155, 161, 164, 183; spirits of, 44, 161; tear glands, 205; tenderness, 98. *See also* Sight

FAIRFAX, THOMAS, ix

Falling stars, 83–85

Fancy, 181; contrasted with reason, 108, 114, 184, 194–195; operation, 144; relation to intellect, 199

Fencing, 191

Fermentation, in brewing, 56; cause of, 45–46, 81, 174; effects, 27, 85, 98, 135, 168, 194; in stomach, 129, 152; subterraneous, 69; time of, 82

Fernel, Jean, 130, 130 *n*

Ferns: maidenhair, 139 *n*, 141; male, 139 *n*, 141

Fir, use in musical instruments, 166

Fire, 36, 42–46; effects, 78, 85–86, 113; effects on magnet, 76; effects on sound, 166; kitchen, 104; mixture with wind in blasts, 98; particles of, 100; place, 21, 40, 47, 48; rain of, 102; tenuity, 38, 73, 210; test of gold, 121; test of silver, 122; transmutation, 41; unsuitable to animal nature, 197. *See also* Flame

Fire-engines, 58

Fire-stones, 113, 116

Fish, 23, 210; breathing, xxiii, 197; breeding and nourishment, 57; effect of loud sound on, 168; phosphorescence of putrid, 84

Fitch, Jabez, 3 *n*

Fitzgerald, Robert, 71 *n*

Flame, affections, 44–45; cause, 43, 81, 157; fluidity, 42; of life, 192; life of brutes compared to, 145; light, 85, 86, 88, 155, 156; matter, 44, 149; motion, 155. *See also* Fire

Fleas, 190, 196

Flies, 147, 196

Fluidity, 37, 38; of air, 49; confusion with humidity, 53; effects, 39, 57, 61, 63, 64; of fire, 142; of water, 53. *See also* Moist

Fluids, 36 *n*, 38, 64; nature of, 40
Flying, 191, 191 *n*; man's hope of, 191, 210
Flying dragon, a fiery meteor, 82
Fountains, artificial, 50; cause, 62, 69, 70; fresh-water, 70; mineral and salt, 62, 72, 125; in mines, 117, 118; place, 70, 98, 99, 114
Foxes, 174
Freestone, use in roofing houses, 116
Frogs, 197; breeding, 147; rains of, 101
Frost, effect, 47; sign of rain, 106; usefulness to health, 52
Fume, 81
Furze-balls, 142
Fusibility, 113, 117, 125; of tin, 122

GADBURY, John, 29, 29 *n*
Gale, Theophilus, xv *n*
Galen, 78 *n*
Galileo, on astronomical measures, 93; defense of Copernican scheme, 24, 25; Morton's knowledge of, 33 *n*, 62 *n*; system condemned by the pope, 23; on tides, 63, 68, 69, 213, 214, 215
Gall, formation, 128, 131; function, 130, 175
Garden, George, 94 *n*
Gassendi, Pierre, xxxix, 15 *n*, 20 *n*, 206 *n*; on Copernican system, 23; on earth's circumference, 32 *n*; on matter, 36
Gataker, Thomas, 30, 30 *n*
Geese, 129
Gems, origin, 114–116, 134; value, 115
Generation, of animals, 143–148, 189, 196; definition, 17–18; of meteors, 47; not observed by ancients in heavenly bodies, 20; principles, xxiii, 10, 12, 13, 207; of stone, 113; of vegetables, 126
Geography, use of eclipses in, 34
Geometry. *See* Mathematics
Gilbert, William, 75 *n*
Ginger, 177
Glands, atrabilious, 128; gastric, 128; pineal, 199; salivary, 128, 131, 176; sweat, 131; tear, 131, 205
Glanvill, Joseph, xxvi
Glass, 125; making of, 45, 86; painting, 124; porousness, 38, 50; specular (*see* Looking glasses); trigonal (*see* Prisms); vibration, 164
Glasshouses, 113
Gloucester Cathedral, whispering-place at, 167
Glowworms, cause of light in, 84
Goddard, Jonathan, xiii
Godolphin, Francis, 121, 121 *n*
Godolphin Ball, 117 *n*, 121
Gold, 119–121; compared with copper and iron, 124–125; compared with lead, 123; compared with silver, 122; porousness, 38
Grafting, of trees, 139–141
Grasshoppers, 190, 197
Gravity, xxiii, 14, 18, 19, 37 *n*, 39, 40, 185; attribute of water, 53, 57–61, 64, 165 *n*, 214; cause of, disputed, 18, 19, 39, 75; center of, xxxi, 26, 54, 187, 191; definition, 73; earth's center of, 64, 69, 216; natural to all bodies, 25
Grease, aid to motion, 39; removal by soap, 56; use in waterproofing, 55
Greenleaf, Daniel, xxxiii–xxxiv, xxxv–xxxvi, 3 *n*
Greenwood, Isaac, xxxi
Gresham College, xii, xiii, xviii–xix, 89 *n*, 93, 139 *n*
Grew, Nehemiah, xiii
Gridley, Jeremiah, xxxii–xxxiii, xxxv
Griffin, Anthony, 29 *n*
Growth, cause, 142; in plants and animals, 134–138
Gunpowder, ingredients of, 55, 85
Guns, cause of sound made by, 164, 169; harmful effects of sound of, 168; mechanism, 87, 168; souring of liquors by, 87, 168; use in pestilences, 52, 168; wind guns, 50

HAIL, a watery meteor, 100, 103
Halo, an appearing meteor, 108, 109, 112

Hannibal, 117, 118 *n*
Hardness, of earth, 73; of iron, 124; a second quality, 38, 42, 78–79, 151, 177; of stone, 79
Harpsichords, 173
Harvard, John, viii, xxi, 79 *n*
—— Robert, viii
—— Thomas, viii, viii *n*
Harvard College, corporation, sponsors "Proposals for Recording Illustrious Providences," xxvii–xxviii; Morton legacy, xxix; Morton's MS. outlines used at, xxiii, xxxi–xxxvi, 3 *n*; objection to Morton's private teaching, xxiv; presidency, xix–xxiii; Stoughton College, xxiv; text-books used at, xxxviii–xxxix
Harvard University Archives, xxxiv, xxxv
Harvey, William, on circulation of the blood, 45 *n*, 131; on embryology, 139 *n*, 146; on quantity of the blood, 193, 193 *n*
Headache, cause of, 175, 178
Health, definition, 126; influence of heavenly bodies on, 29; perspiration essential to, 133; relation of earths and minerals to, 79; relation to growth, 137; sleep essential to, 195
Hearing, 79, 149, 151, 152, 163–173, 181
Heart, anatomy, 131; cooling of, 197; development in embryo, 147; pulse a motion of, 192–193; quantity of blood in, 132, 193; seat of will, 199
Heat, xxiii, xxv; of blood, 197; cause, 33, 45, 56, 59, 95; degrees, 18, 86; effects, 37, 81, 111, 113, 133, 135, 136, 137, 138, 154, 157, 166; held by silver vessels, 122; relation of altitude to, 48, 49; of the sun, 74; sun the fountain of, 47. *See also* Hot
Helena, a fiery meteor, 82
Hematite, medicinal use, 114
Henry Frederick, Prince of Wales, 120, 120 *n*
Herbs, propagation, 140; scent, 175, 176; stewed with mushrooms, 142; use, 208
Hevel, Johann, 192 *n*, 216, 216 *n*
Heydon, Christopher, 30, 30 *n*
Hippocratic Collection, 78 *n*
History, 207; use of eclipses in, 34
Hoar, Leonard, xix, xxii
Hobbes, Thomas, 206 *n*
Hogs, 129, 174, 175
Hollis, Thomas (*d* 1731), xxxi
Hone, 116
Honey, 104–105
Hooke, Robert, xxxix; on astronomical measures, 93; writings relevant to Morton's discussion, 28 *n*, 48 *n*, 89 *n*, 139 *n*
Hooker, Thomas, vii *n*
Hops, effect of sun on, 136–137; use in brewing, 56
Hornberger, Theodore, introduction to Morton's *Compendium*, xxxi–xl
Hornets, 147
Horseradish, 140
Horses, bells and trumpets pleasing to, 170; certain herbs inedible by, 175; phantasms of, 182; teachableness, 196; time of growth, 136; unfit for human food, 127
Horsey, Henry, xx
Hot, chief cause of levity, 39; effects, 142; a first quality, 37–38, 41, 42, 51, 78, 79, 177. *See also* Heat
Hourglass, 16, 38
Humors, ancient theory doubted, 132; cause, 79; expansion of, a cause of pain, 178; of the eye, 152, 153–154; quality, 129; repulsion by medicine, 120, 123
Hunger, cause, 129
Hunting, 174–175

ICE, 37, 42, 106–107
Ignis fatuus, a fiery meteor, 82
Ignis lambens, a fiery meteor, 83
Images, function in apprehension, 150, 151, 153, 181; in memory, 182. *See also* Phantasms

Imagination, 181, 202

Insects, distinction from perfect brutes, 196; procreation, 147–148

Instinct, 175, 182, 185, 195

Iron, 119, 121, 124–125, 127; cause of magnetic influence on, 75; use to stop vibration, 168

Ironside, Gilbert, xiii

Ivy, 136

JACINTH, 115

James II, of England, Declaration of Indulgence, xix

Jet, electrical property of, 76

Jew's-ear, 142

Johnson, Isaac, vii *n*

Johnstone, John, xxxviii *n*

Jumping, 190

Jupiter, 24 (fig.), 32 (fig.); chemical name for tin, 122; conjunction with moon, 28; magnitude, 32 (fig.), 215; moons, 23, 215; motion, 22, 32 (fig.)

KEPLER, JOHANN, 20 *n*, 23

Kestell, John, ix

—— Thomas, vii

Kidney beans, 136–137

Kidneys, separation of urine by, 128, 131, 132

Kittredge, George Lyman, xxv

LACTEAL vessels, 130–131

Lapis caliminaris. See Calamine stones

Lead, 119, 123; inflexibility, 39; medicinal use, 120, 123; mines, 101; mixture with tin for pewter, 122, 125

Leather, preparation, 55

Lee, Samuel, xiii

Leeches, 196

Leeuwenhoek, Anton van, 45 *n*

Legrand, Antoine, writings relevant to Morton's discussions, xxxviii, xxxix, 7 *n*, 16 *n*, 20 *n*, 31 *n*, 32 *n*, 33 *n*, 53 *n*, 73 *n*, 108 *n*, 113 *n*, 126 *n*, 149 *n*, 152 *n*, 174 *n*, 187 *n*, 193 *n*, 194 *n*

Lemnius, Livinus, 79, 79 *n*

Lemon juice, use in removing grease, 56

Leverett, John (*d* 1724), xxiii, xxiv, xxviii

Levity, a second quality, 18, 36 *n*, 39–40. *See also* Gravity

Lice, 196

Light, xxv, xxvi; of appearing meteors, 108–112; cause of, in flame, 44, 149; of fiery meteors, 87; of flame, 44, 86; modification in color, 158–160; phenomena of, xxiii, 155–158; of the planets, 23, 33–35; reception by eye, 153; of stars, 23, 32; of sun, 22, 23, 27, 50, 89, 125

Lightning, 85–87; place of, 48

Lillie, William, 30 *n*

Lime, boiling of, 46, 69, 81; salt of, 55; use of, for preserving seeds, 141; weight, 60

Lindall, Timothy, 3 *n*

Liquors, cold, 46

Lister, Martin, 61 *n*

Liver, separation of gall by, 128, 130, 131

Lixiviums, 57, 60, 87

Lizards, 197

Loadstones, 76, 121. *See also* Magnets

Lobsters, 130

Locomotion, 18, 39, 149, 150, 187–193, 199

Log line, 53, 54, 55

Logic, Aristotelian, xxxvi, 9 *n*; definition, 184, 202; difference from physics in use of *matter* and *form*, 9–11; processes, 200; *quantity* in, 15

Logwood, coloring of water by, 101

Long blaze, a fiery meteor, 87

Looking glasses, 108, 153; images in, 151; making of, 117, 122

Lower, Richard, 193 *n*

Lucretius, xxxviii

Lullius, Raimundus, 121

Lungs, function, 197; relation to voice, 196; respiration a motion of, 192

Lusitanus, Zachutus, 130

MAGNETISM, xxiii, 39, 40, 73 *n*; of the earth, 75; of the moon, 62, 215
Magnets, xiv, 75–76, 114, 124. *See also* Loadstones; Magnetism
Malpighi, Marcello, 45 *n*
Malt, 56
Man, distinction from brute, 7, 11, 146, 196, 198–205
Manna, 104, 105–106
Maple, use in musical instruments, 164
Maps, making of, 31, 54
Marble, use as building-stone, 116
Marcasite, 125
Marl, use in improving land, 116
Marriott, Obadiah, xx *n*
Mars, chemical name for iron, 124; color, 90; conjunction with moon a sign of windy weather, 28; magnitude, 32 (fig.); motion 22, 32 (fig.); position, 23; significance of, in destroying Ptolemaic system, 24
Massachusetts Historical Society, xxxii, xxxiii, xxxv, 3 *n*
Mathematics, branches of: algebra, 202; arithmetic, 26 *n*, 78, 171, 201, 202; geometry, 25, 31, 34, 78, 79, 120; mechanics, xxiii, 59; optics, 4, 103, 108–112, 151, 153, 157, 160–161, 176; trigonometry, 68; difference from physics in use of *body*, 15, 124; of music, 170–173
Mathematical instruments, xiv, xvi, xxxi, 124. *See also* Microscopes; Telescopes
Mather, Cotton, and witchcraft, xxv *n*, xxvi, xxvii, xxviii
—— Increase, xix, xx *n*, xxi, xxviii, 165 *n*; on the evil eye, 161 *n*; rector of Harvard College, xxiii, xxiv; and witchcraft, xxvi, xxvii
—— Samuel (*d* 1671), x, x *n*
Matter, 3, 15, 16, 17, 21, 37, 38, 78, 85, 98, 126, 149, 187, 189, 200, 206, 207; celestial, 76; combustible, 86, 145, 154; of comets, 89–91; conservation, xxiii, 73; definition, 9–14; Descartes on, 26, 310; ethereal, 50; first and second, 13–14; of flame, 44, 81, 83; indestructibility, 18, 209; of light, 155, 156; modification, 42, 80, 188; motion of, a cause of fire, 43; putrid, 196; of seed, 143
Mayerne, Theodore Turquet de, 120, 120 *n*
Medicine, as aid to digestion, 129; ancient, 78 *n*; complexions in, 79; knowledge of physics useful in, 3, 4, 5; object, body as healable, 7; purpose, 127; use of copper in, 124; use of gold in, 119, 120; use of lead in, 123; use of plants in, 79, 142; use of scents in, 175; use of stones in, 114
Memory, 151, 180, 182–184; of animals, 149, 188; intellectual, 194, 202
Mercator, Gerard, 31 *n*
Mercury, an active particle, 36, 75; in barometer, 51, 52; component of metal, 117, 119; medicinal use, 120; a middle mineral, 125; steam, 120; use in making looking glasses, 122; weight, 123
Mercury (mythology), 29
Mercury (astronomy), magnitude, 32 (fig.); motion, 22; position, 22–23, 24 (fig.), 32 (fig.)
Merret, Christopher, 117 *n*
Metals, 7, 74, 75, 76, 117–125; elasticity, 39; fusibility, 113; melting, 27, 86
Meteors, 7, 20; airy, 94–99; appearing, 108–112; fiery, 81–88; generation, 47; influence of heavenly bodies on, 28; watery, 100–107
Miasmas, 52, 175
Mice, 147
Microscopes, discoveries made with, 139 *n*, 142, 159, 191, 196
Mildew, 104–105
Miller, Perry, 200 *n*
Mine damp, 118
Mineral waters, 60, 72
Minerals, 7, 79; formation, 62; fusibility, 113, 125; nitro-sulphurious, 69; salt of, 46; steams, 75, 85, 101; taint in drinking water, 72, 125

Mines and mining, 117–118; lead, 101; silver, 122; tin, 121 *n*; water in, 70

Mint, 140

Minute glass, use by mariners, 53

Mist, 103–104

Mistletoe, 142

Moist, a first quality, 27, 37, 41, 43, 45, 47, 50, 51, 53, 69, 74, 78, 79, 81, 85, 86, 100, 113, 136, 137, 138, 142, 147, 148, 166, 174, 177, 197. *See also* Fluidity

Moles, 197

Monkeys, 197

Monochords, 170

Monsoons, 94 *n*, 95–96

Moody, Joshua (*d* 1697), xxi, xxii, xxvii

Moon, conjunction with Venus or Jupiter, 28; distance from earth, 93; eclipses, 34, 74; habitableness, 34, 208; halo, 108; hibernation of birds in, 192 *n*; hills and dales in, 20, 33; influence, 27, 213; light, 33; magnitude, 32 (fig.), 89, 92; man in the, 33; measure of months, 16; motion, 22, 32 (fig.); orb, 40, 43; paraselene, or mock, 108; position, 23, 24 (fig.); relation to tides, 62, 66, 67, 213–217

Moonwort, 141

Moore, Norman, 120 *n*

Morison, Samuel E., biographical sketch of Charles Morton, vii–xxix

Morland, Samuel, 164

Morley, Thomas, 170 *n*

Morton, Charles, biographical sketch, by S. E. Morison, vii–xxix

—— John, viii, viii *n*

—— Nicholas, vii–ix

—— Nicholas, Jr., viii, viii *n*

Mosses, observation by microscope, 142

Motion, xxiii, xxv, 15, 39, 40, 73; of animals, 149, 152, 187–193; anti-Aristotelian concept of, 11 *n*; of the atmosphere, 94–95; of atoms in magnetism, 75; of comets, 89, 90, 91–92; definition, 14; of the earth, 76, 93; of flame, 44, 155; of heavens in general, 21–27, 34; of light, 155–157; of matter, cause of fire, 43, 45; measured by time, 16–17; of natural spirits, 45, 144–145, 170, 171, 172–173; object of two senses, 150, 181; of planets, 31 *n*, 32 (fig.), 33; of plants, 17–19; of tides, 62–69, 213–218; of volatile particles, 46; of water, 53, 57–59; of waves, 165

Moxon, Joseph, 94 *n*

Mundic, 117 *n*, 125

Mushrooms, 142

Music, 167–173, 176, 201; of the spheres, 22

Musk, 176

NANTWICH, Eng., salt springs, 62, 62 *n*

Nature, definition, 14; God of, 143; law of, 19, 25, 26, 36, 39, 58, 66, 73, 136, 207; mystery of, 4, 124; necessity of touch in, 178; phenomena of, 3, 181; present state of, 208; principles, 14, 19; species, 210; struggle, 47; tones in, 170; work, 100

Navigation, danger of storms, 98; icebergs encountered in, 106; obtaining fresh water at sea, 71; rowing of boats, 191; use of loadstone, 124; use of log line and minute glass, 53–54; use of tides, 62

Neoterics, 134 *n*, 144

Nerves, 198; of backbone, 187; of the ear, 163, 164, 172; gustatory, 176; of motion and sense, 178; optic, 44, 152–153, 154, 155, 161, 164; sensitive, 180; spirits in, 187; of touch, 177

Nervous liquor, 128, 129

Nervous spirits, 177

Newington Green Academy, xv–xviii

Newton, Isaac, xxxi, xxxvi, 152 *n*, 206 *n*

Nightshade, 136

Niter, cause of ice, 106; constituent of

Niter (*continued*)
fulmen, 85–86; of the earth, 113; fumes, 81, 82; of minerals, 69; particles, 42, 98; of snow and hail, 102–103; steams, 102
Nourishment, by alimentary parts, 12, 189; of animals, 127–132, 143; of embryo, 146; of plants, 126–127
Nowell, Samuel, xix

OAK tree, 142
Oakes, Urian, xix
Object glass, 151, 160
Oil, aid to motion, 39; of malt, 56; matter of flame, 44; weight, 60
Oldenburg, Henry, 28 *n*
Ore, 117; iron, 124; silver, 122
Otters, 197
Ovid, xxxviii
Oxford University, Wadham College, x–xii

PAIN, cause, 178; of hunger, 129
Palate, 127, 176
Palmer, Samuel, xvii *n*
Palsy, cause, 120; symptoms, 152, 178
Paracelsus, 121
Parallax, of comets, 92
Paraselenae, 108, 108 *n*
Parhelia, 108, 108 *n*, 109, 111
Paris, Samuel, xxvi
Parrots, 205
Partridge, William, xxxiii
Partridges, 174
Pascal, Blaise, 48 *n*, 51
Passions, 185–186, 204, 205; in animals, 149; effect of vehemence of, 182; effect on eye, 161; of light, 158; part of sensation, 150; relation to health, 28
Pears, 140
Pendulums, motion, 18, 26, 63; relation of length of string to time of vibration, 67; use in measurement of time, 54–55, 86
Penetration of dimensions, impossibility of, 50, 156, 210
Penhallow, Samuel, xx, xxiv
Pepper, 177
Perception, in animals, 187, 188; processes, 44, 150–151. *See also* Hearing; Sight; Smell; Taste; Touch
Peristaltic motion, 130
Perspiration, a cure for fat, 138; of the eye, 161; glands, 131; importance, 133; vinous spirits lost in, 83
Petty, William, xi, xii; on cause of elasticity, 39; on duplicate proportion, 15, 15 *n*, 115; on place, 16; on time, 17; on value of gems, 115
Pewter, composition, 122, 123, 125; freezing of water in dish of, 107
Phantasms, function, 180–182, 194, 195, 200, 202. *See also* Fancy; Images
Philosopher's stone, 121, 122
Phips, Lady Mary, xxii
Phips, Sir William, xxvii
Physiology, 28 *n*, 126 *n*, 187 *n*; of digestive system, 127–133; of muscular motion, 187–189
Pitch, 55
Place, 3, 10 *n*; definition, 15–16
Placenta, 132
Planets, affections, 32–35; comets considered as, 89; conjunctions, 117; creation, 25–27; definition, 31; habitableness, 208; influence, 29; motion, 18, 22, 25, 91, 215; orbs of, 21; position, 22, 23, 24 (fig.), 50
Plants, aid in finding metals, 117; complexion, 79; definition, 7, 126; distinction from animals, 149; growth, 134–138; injury to, by lightning, 86; injury to, by storm, 98; life of, lived by men, 146; nourishment, 102; propagation, 139–142; source of honey, 105; species, 142–143; spirit, 189; steams, 104; suitable soil necessary for, 74. *See also* Vegetables
Plaster of Paris, 38, 115
Plastic virtue, in animal procreation, 143, 199; in the earth, 139; in seed, 136, 137–138
Platonic year, 22, 22 *n*, 27

Platonists, 206
Pliny the Elder, 114, 114 *n*
Plums, 140
Pneumatics, science of, 145, 198, 199
Poetry, aid to memory, 184; order in, 206
Poliphant, 116
Pope, Walter, xiii
Popery, 29, 203
Pores, of the earth, 70; of human body, 45, 52, 128, 133
Porousness, an aid to motion, 36; of glass, 50; of plants, 140; a second quality, 38, 73; of water, 56, 106
Potash, manufacture, 55, 60
Power, Henry, xxxix; on duration of the world, 209, 209 *n*; on weight of the atmosphere, 51, 51 *n*
Precipitation, 56, 72, 119
Priestley, Joseph, xix *n*
Primum mobile, 21, 22, 23, 24 (fig.), 31, 91
Printing, improvement of, 4; type, 206
Prisms, xxxi, 159, 160
Privation, definition, 9–10; of heat, 47; of light, 44, 45, 156–157; of light's reflection, 158; of motion, 19; of touch, 178
Procreation, animal, 139, 143–148; vegetable, 126, 139–142
Prognostics, of fortune, 82; of weather, 28 *n*, 104, 108, 110, 111, 112
Proportion, arithmetical, 78; geometrical, 79; rule of, 51
Prosthaphæresis, 68, 69
Proverbs: on Hingston Down, 118, 118 *n*; on hunger, 129; on the number of the stars, 31; on a poor man's sow, 174; on the rainbow, 111
Providence, in determination of sex, 143; extent of, 190; meditation on works of, 4; slight of, by atheists, 29
Ptolemy, 20 *n*, 21–22, 23, 24 (fig.), 64
Pulse, 132, 192–193
Pumps, 59–60, 71, 118
Punk, 142
Putrefaction, cause of offensive odors, 175; of fish, 84; in human bodies, 133; not a cause of generation, 147–148; of sea water, 62, 71; of wet hay, 43
Pythagoras, 20 *n*, 22

QUALITIES, first and second, 37–41. *See also* Cold; Dry; Hot; Moist
Quicksilver. *See* Mercury
Quinces, 139

RAIN, 100–102; carrier of seed, 141; cause of growth in plants, 135; cause of springs, 70; clouds, 85, 94; difference from dew, 104; difference from mist, 103; falling stars a sign of, 83; lack of, on high mountains, 48; rainbow a prognostic of, 111; relation to health, 52; in thunderstorms, 86
Rainbow, 108 *n*, 109–112; colors of, 111, 159, 160; of an egg, 147; of the eye, 147
Randolph, Edward, xx, xx *n*, xxii
Rarefaction, of air, 50; in animals, 135; of the parts of meat, 56; of water, 43
Rarity, a second quality, 38
Ratiocination, 126; process of, 161, 207; unfitting of brain for, by madness, 182. *See also* Reason
Reason, 27, 161; logic, the art of, 200; not the distinction between brutes and men, 196, 198; place of, in dreams, 195. *See also* Ratiocination
Redi, Francesco, 139 *n*
Reflection, of colors, 159, 160; of light, 27, 33–34, 84, 89, 110, 153, 156, 157, 158, 160; of sound, 166–167; of the sun, 109; of sunbeams, 47, 48, 49, 50, 94
Refraction, of light, 156, 157; by prism, 159, 160; rules of, 160; by spectacles, 154; transparence necessary for, 158
Religion, distinction of man from brute, 196, 198, 204
Respiration, of animals, 196, 197; aptness of atmosphere for, 51, 52; as

Respiration (*continued*)
basis of distinction between insects and perfect animals, 196; function of, 131, 192
Rest, opposite of motion, 19; a principle of body, 14; principle of matter, 73, 80
Resurrection, alimentary parts not subject to, 12; soul and body united after, 10
Revelation, by dreams, 195
Riccioli, Giovanni Battista, 215, 215 *n*
Rice, 142
Rogers, John (*d* 1684), xix
—— Nathaniel (*d* 1655), vii *n*
—— Nathaniel (*d* 1745), xxxv
Rohault, Jacques, xxxviii
Rooke, Lawrence, xii, xiii
Rosicrucians, 117
Royal Society of London, xi–xiv, xxxvi, xxxix; interest in whispering-place at Gloucester, 167 *n*; interest in peak of Teneriffe, 48 *n*; *Philosophical Transactions*, 48, 91, 213; Morton and, xxxvi, 116 *n*; interest in starshoot, 83 *n*; interest in weather, 28, 28 *n*
Rubies, 115
Rye, 140

SALAMANDERS, 197
Salt, acid, 46; an active particle, 36, 37, 45, 55, 75, 113, 176, 178; crystallization, 115, 158; mineral, 46, 61, 134, 174; taste, 176, 177; vegetable, 46, 55, 56, 71, 159; vitriol, 115
Saltmaking, 62
Saltpeter, 61, 75
Salt water, 57, 61–62, 71
Salusbury, Thomas, 33 *n*
Sancroft, William, xx *n*
Sanctorius, 133, 133 *n*
Sandarac, 105
Sap, 134
Sassafras, 175
Saturn, 31; chemical symbol for lead, 123; color, 90; conjunction with moon, 28; magnitude, 32 (fig.); moons, 23, 215; motion, 22, 32 (fig.); position, 23, 24 (fig.)
Scales, 60
Scholasticism, xxxvi *n*, xxxvii, xxxviii, 7 *n*, 9 *n*, 185, 207
Scrofula, 120
Sea, 61–69; in the moon, 33; saltness of, 61–62, 71; source of all waters, 189; tides, 23, 62–69, 213–218
Sensation, 126, 149–151, 152–184, 187, 193, 194, 195, 199
Sermons, 175, 184, 202
Serpents, motion, 191; shape, 136
Sewall, Samuel (*d* 1730), xx *n*, xxi, xxviii
Sex, in animals, 143; in plants, 139 *n*, 140
Shepard, Thomas (*d* 1649), xix, xxi
Shipbuilding, caulking of hulls, 55; sheathing of ships with lead, 123
Shower, John, xvi
Sight, 9, 14, 79, 149, 151, 152–162, 171, 177, 180. *See also* Eye
Signatures, 144, 181
Silkworms, 147, 148
Silver, 119, 122; ductility, 120, 123; imitation of, 122, 124
Silversmiths, 171
Silver tree, 122
Siphons, xxxi, 58, 59
Slate, 114, 116
Sleep, 193, 194, 195; cause, 175; memorizing in, 184; need of, 147
Slegel, Paulus Marquart, 192 *n*
Smell, 151, 174–176; in animals, 127
Snails, 130, 191
Sneezing, 175
Snell, Willebrod, 32 *n*
Snow, 100, 102–103; adhesiveness, 206; difference from ice, 106; on mountains, 48, 96
Soapmaking, 55–56, 60
Softness, a second quality, 38, 80
Soils, variety of, 74
Solder, composition, 122
Soul, animal, 149, 188–190; creation of, 143, 210; human, 198–199; of

metal, 120–121; perception by, 44, 162; powers, 152, 181, 200, 203; seat of, 21, 174; union with body, 10–12, 13, 126, 144, 145–146; of the universe, 189, 206; vegetable, 126
Sound, xxiii, 163–173; perception of, 79, 150
Speaking trumpets, xvi, 165 *n*
Specific gravity, 57, 119
Spencer, John, 89 *n*, 93
Spieghel, Adrian van den, 192 *n*
Spontaneous generation, denied, 147–148
Sprat, Thomas, xiii
Springs. *See* Fountains
Star-shoot, 83–84, 83 *n*, 90
Star stones, 101
Stars, composition, 36; falling, 83, 85; fixed, 22, 23, 24, 28, 31–32, 161, 208; influence, 29; wandering, 23, 31 (*see also* Planets)
Steams, cold, 27, 47
Steel, ductility, 123; elasticity, 39, 125; flint and, 43
Steel mills, 113
Sterling, 119
Stomach, agreeableness of food to, 174, 176; digestion in, 127–130; heat, 120; of insects, 196
Stone, 113–116; gravity, 185; growth, 134; mineral, 117; transparent, 159; unsuitable for food, 127
Storms, cause, 98; effect on tides, 63, 66; place, 48; seasonal, 95
Stoughton, William, x, xx, xx *n*, xxiv, xxvi, xxvii, xxix
Sulphur, an active element, 36, 56, 75, 86, 102, 106; cause of subterraneous fires, 69; in flame, 44, 81; fossil, 82; ingredient of gunpowder, 85; levity, 37, 45, 60, 85, 98; a middle mineral, 125; in potash, 55; a principle of body, 36, 85, 117, 119; spirits, 130; volatility, 174
Sun, cause of clouds, 47; clouds in the, 20; composition, 36; conjunction with moon, 27; eclipses, 34; evaporation by, 61, 81, 95, 96, 100, 102, 103; heat, 43, 48, 49, 70, 101, 105; influence on motion of planets, 66, 67, 214, 215; influence on plants, 136, 137; light, 33, 44, 84, 89, 90, 92, 155, 156, 159; motion, 16, 22, 23, 27, 32 (fig.), 215, 216, 217, 218; motion of apogee, 209; position, 22, 23, 24 (fig.), 32, 64, 66; reflection, 108, 109, 110, 111; uninhabitableness, 208
Swimming, 39, 61, 100, 190, 191, 197

TALLOW, 55
Tar, 55
Tartar, spirit of, 46, 81
Taste, 79, 151, 176–177; in animals, relation to smell, 127; nauseous, of liquors standing in brass vessels, 124; necessary to swallowing, 127
Tears, 131, 205
Telescopes, xiii; discoveries made with, 20, 23, 31, 32, 33
Temperament, 78–80; of the brain, 183, 199; cold, 138; of the heart, 199; influence of heavenly bodies on, 28
Tendons, 153, 187
Tenuity, a second quality, 38, 43, 162. *See also* Porousness
Theophrastus, 134 *n*
Thermometers, xiv, xvi, 50
Thunder, cause, 85–87, 102; place, 48, 98; sound, 99, 164; souring of liquors by, 87, 168
Tides, 23, 62–69, 213–218
Time, an Aristotelian category, 10 *n*; definition, 16–17; of growth of animals, 136; of growth of trees, 140; necessary to body in general, 3, 15; of planetary motion, 22; of the pulse, 192–193; of revolution of the *primum mobile*, 22; shown by clocks, 14; of sounds, 167–168
Tin, 119, 122–123; composition, 117; gold, the soul of, 121; mining, 116, 118; use in making bell metal, 124; use in making pewter, 125

Tobacco, 82, 88

Topaz, 115

Torricelli, Evangelista, experiment on weight of the air, xxxi, 51, 59; hydrodynamics of, 57 *n*

Tortoises, 197

Touch, 79, 151, 174, 177–179

Touchstone, a test of gold, 121; a test of silver, 122

Toughness, a second quality, 38–39

Toulmin, Joshua, xvii *n*

Trade winds, 23, 94–95

Transmutation, denied, 40–41; of metals, 123. *See also* Alchemy

Transparency, a cause of color, 158, 159; of the heavenly orbs, 21; of the horny coat of the eye, 153; of precious stones, 114

Trees, growth, 135; propagation, 139–140; shape, 136

Trigonal glass, use in study of colors, 159, 160

Tropics, fiery meteors in, 82; winds in, 23, 94–95

Turquoises, 115

URINE, acid stain of, 159; distillation, 71; function, 133; passages for, 132; separation, by the kidneys, 128, 131; stoppage, 178

VACUUM, abhorred by nature, 14, 39, 48 *n*, 50, 59, 86, 164, 210; aid to motion, 36, 210

Van Helmont, J. B., 121

Veel, Edward, xviii

Vegetables, composition, 79; definition, 126; growth, 134; lack of, on high mountains, 48; nourishment, 75; salt of, 46, 55, 62; soul, 126, 189

Veins, 131, 152, 198; emulgent, 128; function, 192; jugular, 131; lacteal, 130; mesenteric, 130; navel, 132

Velocity, of the earth, 64–66, 215; of falling bodies, xxxi, 25–26, 40; of light, 157; of running water, measurement of, 54–55, 57

Vena cava, 131, 132, 147

Venus, appearance of, through telescope, 33; chemical name for copper, 123; conjunction with moon, 28; magnitude, 32 (fig.); motion, 22, 32 (fig.); position, 22, 23, 24 (fig.)

Verdigris, 124

Vibration, of air, 164, 188; deadening of, by hangings, 166; of liquors, 168; of nerves, 178; of nervous spirits, 177; of strings, 169, 170, 170 *n*; of wings of insects, 196

Vinegar, canker of lead by, 123; coloring of water by, 101; cutting resinous bodies with, 56; Hannibal's use of, 117, 118 *n*

Viper stone, 114

Virginia creeper, 136

Vitriol, of copper, 124; crystallization, 113, 115; of mundic, 125; spirits, 46, 56, 101, 130; steams, 87

WALKING, 190–191

Wallis, John, xii, xxxv, xxxix; on tides, 62 *n*, 63, 68, 213–218; on vibrating strings, 170 *n*

Walnuts, 141

Ward, Robert, xxxv, 192 *n*

—— Seth, xii

Washing, 55, 56, 71

Wasps, 147

Water, 53–72, 76, 100–107; coldness, 41, 42, 53; compared with light, 155; evaporation, 41; extinguishes fire, 43–44; fluidity, 37–38, 42, 53, 55–57; gravity, 57–61; home of fish, 197; humidity, 41, 42, 53; medium of light, 160; medium of sound, 173; mixture with wind, in storm, 98; in the moon, 20, 33; part of fulmen, 85; particles of, in clouds, 84, 94, 98; principle of body, 36, 45; reciprocating movement, 62–69, 213–218; region of, 21, 40, 47, 53; regulation of, in agriculture, 74; specific gravity tested by, 18, 39–40, 50, 60–61; tenuity, 38; waves, 165; weight, 132

Water drinker, 101, 101 *n*
Waterspouts, 99
Waterwheels, 58, 118
Waterworks, 58
Wax, color, 159; electrical property, 76; hardness, 38; simile of, in discussion of figure, 11–12, 13, 188
Weapon salve, 124
Weather, cold, 148; influence of heavenly bodies on, 27, 28, 29; prognostication of, 28, 103, 108, 111, 112, 148
Weather glasses, 50, 52
Webb, John, xxxiv
Wesley, Samuel, xvi, xvii–xviii, xviii *n*, 165 *n*
Whirlwinds, 87, 97, 101
Whiting, Samuel (*d* 1679), vii *n*
Widdowes, Daniel, xxxviii *n*
Wilkins, John, x, xi *n*, xii, xiii, xiv, 20 *n*; on conquest of the air, 191 *n*; on Copernican scheme, 23, 24; on weather forecasting, 28 *n*
Will, 203–204; actions, 186; seat, 199
Willard, Samuel (*d* 1707), xxvi, xxvii
Willis, Thomas, xii, 149 *n*
Willows, 139
Winds, 94–99; artificial conveyance of, 112; carriers of seed, 141; effect on fire, 43; healthfulness, 52; light effects, caused by, 158; partial cause of hail, 103; prevention of rust by, on corn, 105; prognosticated by reddish halo, 118; trade, 23, 94–95; in tropics, 23, 94–95
Wine, fermentation, 82; nourishment by odor of, 174; reflection of light by, 89; spirit of, 43; weight, 60
Witchcraft, xxv–xxvii, 161, 161 *n*; John Dee accused of, 28 *n*
Wolves, 174
Womb, 175
Wool, 39, 49–50
World, 206–210; Aristotle's eternal, 22; bounds to, 15; center, 14, 22, 23, 27, 32; creation, 25, 91, 109, 207; definition, 8; poles, 76; preservation, 14, 18; several systems of, 21–24; visible and invisible, 20–21
Wren, Sir Christopher, xii, xiii

YALE University Library, xxxiii, xxxiv

ZODIAC, 22

#95